# Official 47-Passage 01 Roman Cultural Influence on Britain

    After **the** Roman **Empire**’s conquest **of** **Britain** **in** **the** **first** **century** **A**.D., **the** presence **of** administrators, **merchants**, **and** **troops** **on** **British** **soil**, **along** **with** **the** **natural** **flow** **of** **ideas** **and** **goods** **from** **the** **rest** **of** **the** **empire**, **had** an enormous **influence** **on** **life** **in** **the British** Isles. Cultural **influences** **were** **of** **three** **types**: **the** **bringing** **of** **objects**, **the** transfer **of** craft **workers**, **and** **the** **introduction** **of** massive **civil** **architecture**. **Many** **objects** **were** **not** **art** **in** **even** **the** broadest **sense** **and** comprised utilitarian items **of** **clothing**, utensils, **and** **equipment**. **We** **should** **not** underestimate **the** **social** **status** **associated** **with** **such** mundane **possessions** **which** **had** **not** previously **been** **available**. **The** **flooding** **of** **Britain** **with** **red**-gloss pottery **from** Gaul (**modern**-**day** **France**), **decorated** **with** **scenes** **from** **Classical** mythology, **probably** **brought** **many** **into** contact **with** **the** **styles** **and** artistic **concepts** **of** **the** Greco-Roman **world** **for** **the** **first** **time**, **whether** **or** **not** **the** symbolism **was** **understood**. **Mass**-**produced** **goods** **were** **accompanied** **by** fewer **more** aesthetically impressive **objects** **such** **as** statuettes. **Such** **pieces** **perhaps** **first** **came** **with** **officials** **for** **their** **own** **religious** worship; **others** **were** **then** **acquired** **by** **native** **leaders** **as** diplomatic **gifts** **or** **by** **purchase**. **Once** **seen** **by** **the** **natives**, **such** **objects** **created** **a** fashion **which** rapidly **spread** **through** **the** **province**.

**In** **the** **most** **extreme** instances, **natives** literally **bought** **the** **whole** **package** **of** Roman **culture**. **The** Fishbourne villa, **built** **in** **the** **third** **quarter** **of** **the** **first** **century** **A**.D., **probably** **for** **the** **native** client **king** Cogidubnus, amply illustrates **his** Roman pretensions. **It** **was** **constructed** **in** **the** **latest** **Italian** **style** **with** **imported** **marbles** **and** stylish mosaics. **It** **was** lavishly **furnished** **with** **imported** **sculptures** **and** **other** **Classical** **objects**. **A** **visitor** **from** Rome **would** **have** recognized **its** **owner** **as** **a** participant **in** **the** **contemporary** **culture** **of** **the** **empire**, **not** **at** **all** provincial **in** **taste**. **Even** **if** **those** **from** **the** **traditional** **families** **looked** **down** **on** **him**, **they** **would** **have** **been** **unable** **to** **dismiss** **him** **as** uncultured. **Although** exceptional, **this** demonstrates **how** **new** cultural **symbols** **bound** provincials **to** **the** **identity** **of** **the** Roman **world**.

**Such** **examples** established **a** **standard** **to** **be** **copied**. **One** **result** **was** an influx **of** craft **workers**, particularly **those** **skilled** **in** artistic **media** **like** **stone**-**carving** **which** **had** **not** **existed** **before** **the** conquest. **Civilian** **workers** **came** mostly **from** Gaul **and** **Germany**. **The** magnificent **temple** **built** **beside** **the** **sacred** **spring** **at** **Bath** **was** **constructed** **only** **about** **twenty** **years** after **the** conquest. **Its** detail **shows** **that** **it** **was** **carved** **by** **artists** **from** **northeast** Gaul. **In** **the** **absence** **of** **a** **tradition** **of** **Classical** **stone**-**carving** **and** **building**, **the** **desire** **to** **develop** Roman amenities **would** **have** **been** **difficult** **to** fulfill. Administrators **thus** **used** **their** **personal** contacts **to** **put** **the** Britons **in** **touch** **with** **architects** **and** masons. **As** **many** **of** **the** **officials** **in** **Britain** **had** **strong** **links** **with** Gaul, **it** **is** **not** **surprising** **that** **early** Roman **Britain** **owes** **much** **to** craft **workers** **from** **that** **area**. **Local** workshops **did** **develop** **and** stylistically **similar** **groups** **of** **sculpture** **show** **how** **skills** **in** **this** **new** **medium** **became** **widespread**. Likewise **skills** **in** **the** **use** **of** mosaic, **wall** **painting**, ceramic **decoration**, **and** **metal**-**working** **developed** **throughout** **the** **province** **with** **the** eventual emergence **of** characteristically Romano-**British** **styles**.

**This** **art** **had** **a** **major** impact **on** **the** **native** **peoples**, **and** **one** **of** **the** **most** **important** factors **was** **a** **change** **in** **the** scale **of** **buildings**. Pre-Roman **Britain** **was** highly localized, **with** **people** rarely traveling **beyond** **their** **own** region. **On** occasion **large** **groups** amassed **for** **war** **or** **religious** **festivals**, **but** **society** **remained** centered **on** **small** communities. **Architecture** **of** **this** era **reflected** **this** **with** **even** **the** largest **of** **the** fortified **towns** **and** **hill** forts **containing** **no** **more** **than** clusters **of** **medium**-**sized** structures. **The** **spaces** **inside** **even** **the** largest roundhouses **were** **modest**, **and** **the** **use** **of** **rounded** **shapes** **and** organic **building** **materials** **gave** **buildings** **a** **human** scale. **But** **the** **effect** **of** Roman **civil** **architecture** **was** significant. **The** sheer **size** **of** **space** enclosed **within** **buildings** **like** **the** basilica **of** **London** must **have** **been** **astonishing**. **This** **was** an **architecture** **of** dominance **in** **which** **subject** **peoples** **were** literally **made** **to** **feel** **small** **by** **buildings** **that** epitomized imperial **power**. Supremacy **was** accentuated **by** **the** unyielding **straight** **lines** **of** **both** individual **buildings** **and** **planned** **settlements** **since** **these** **too** **provided** **a** **marked** contrast **with** **the** **natural** curvilinear **shapes** dominant **in** **the** **native** realm.

count: 252

# Official 49-Passage 02 Movable Type

**Nothing** **divided** **the** medieval **world** **in** **Europe** **more** decisively **from** **the** **Early** **Modern** **period** **than** **printing** **with** movable **type**. **It** **was** **a** **German** **invention** **and** **the** culmination **of** **a** **complex** **process**. **The** **world** **of** antiquity **had** **recorded** **its** **writings** mainly **on** papyrus. **Between** 200 B.C. **and** **A**.D. 300, **this** **was** supplemented **by** vellum, calf **skin** **treated** **and** **then** **smoothed** **by** pumice **stone**. **To** **this** **in** **late** Roman **times** **was** **added** parchment, similarly **made** **from** **the** **smoothed** **skin** **of** **sheep** **or** **goats**. **In** **the** **early** **Middle** **Ages**, **Europe** **imported** an industrial **process** **from** **China**, **which** **turned** **almost** **any** **kind** **of** fibrous **material** **into** pulp **that** **was** **then** **spread** **in** **sheets**. **This** **was** **known** **as** **cloth** parchment. **By** **about** 1150 **the** **Spanish** **had** **developed** **the** **first** mill **for** **making** **cheap** **paper** (**a** **word** contracted **from** “papyrus,” **which** **became** **the** **standard** **term**). **One** **of** **the** **most** **important** **phenomena** **of** **the** **later** **Middle** **Ages** **was** **the** **growing** availability **of** **cheap** **paper**. **Even** **in** **England**, **where** **technology** lagged **far** **behind**, **a** **sheet** **of** **paper**, **or** **eight** octavo **pages**, **cost** **only** **a** **penny** **by** **the** fifteenth **century**.

**In** **the** **years** 1446-1448, **two** **German** goldsmiths, Johannes Gutenberg **and** Johann Fust, **made** **use** **of** **cheap** **paper** **to** **introduce** **a** critical improvement **in** **the** **way** **written** **pages** **were** reproduced. **Printing** **from** **wooden** **blocks** **was** **the** **old** **method**; **what** **the** **Germans** **did** **was** **to** **invent** movable **type** **for** **the** letterpress. **It** **had** **three** merits: **it** **could** **be** **used** repeatedly **until** **worn** **out**; **it** **was** **cast** **in** **metal** **from** **a** mold **and** **so** **could** **be** renewed **without** **difficulty**; **and** **it** **made** **lettering** **uniform**. **In** 1450, Gutenberg **began** **work** **on** **his** Bible, **the** **first** **printed** **book**, **known** **as** **the** Gutenberg. **It** **was** **completed** **in** 1455 **and** **is** **a** marvel. **As** Gutenberg, **apart** **from** **getting** **the** **key** **idea**, **had** **to** solve **a** **lot** **of** **practical** **problems**, **including** imposing **paper** **and** **ink** **into** **the** **process**, **and** **the** **actual** **printing** **itself**, **for** **which** **he** **adapted** **the** screw **press** **used** **by** winemakers, **it** **is** **amazing** **that** **his** **first** **product** **does** **not** **look** **at** **all** rudimentary. **Those** **who** **handle** **it** **are** **struck** **by** **its** clarity **and** **quality**.

**Printing** **was** **one** **of** **those** **technical** **revolutions** **that** **developed** **its** **own** momentum **at** **extraordinary** **speed**. **Europe** **in** **the** fifteenth **century** **was** **a** **place** **where** intermediate **technology**—**that** **is**, workshops **with** **skilled** craftspeople—**was** **well** established **and** **spreading** **fast**, **especially** **in** **Germany** **and** **Italy**. **Such** workshops **were** **able** **to** **take** **on** **printing** **easily**, **and** **it** **thus** **became** **Europe**’s **first** **true** **industry**. **The** **process** **was** **aided** **by** **two** factors: **the** **new** **demand** **for** **cheap** **classical** **texts** **and** **the** **translation** **of** **the** Latin Bible **into** “**modern**” **languages**. **Works** **of** **reference** **were** **also** **in** **demand**. **Presses** **sprang** **up** **in** **several** **German** **cities**, **and** **by** 1470, Nuremberg, **Germany**, **had** established **itself** **as** **the** center **of** **the** **international** **publishing** **trade**, **printing** **books** **from** 24 **presses** **and** **distributing** **them** **at** **trade** **fairs** **all** **over** **western** **and** **central** **Europe**. **The** **old** monastic scriptoria—monastery workshops **where** monks **copied** **texts** **by** **hand**—worked closely **alongside** **the** **new** **presses**, **continuing** **to** **produce** **the** luxury **goods** **that** movable-**type** **printing** **could** **not** **yet** **supply**. **Printing** **aimed** **at** **a** **cheap** **mass** **sale**.

**Although** **there** **was** **no** **competition** **between** **the** **technologies**, **there** **was** rivalry **between** **nations**. **The** Italians **made** **energetic** **and** **successful** **efforts** **to** **catch** **up** **with** **Germany**. **Their** **most** **successful** scriptorium quickly **imported** **two** **leading** **German** **printers** **to** **set** **up** **presses** **in** **their** **book**-**producing** **shop**. **German** **printers** **had** **the** **disadvantage** **of** **working** **with** **the** **complex** typeface **that** **the** Italians sneeringly **referred** **to** **as** “Gothic” **and** **that** **later** **became** **known** **as** **black** **letter**. **Outside** **Germany**, readers **found** **this** typeface disagreeable. **The** Italians, **on** **the** **other** **hand**, **had** **a** **clear** typeface **known** **as** roman **that** **became** **the** **type** **of** **the** **future**.

Hence, **although** **the** **Germans** **made** **use** **of** **the** **paper** **revolution** **to** **introduce** movable **type**, **the** Italians **went** **far** **to** regain **the** initiative **by** **their** artistry. **By** 1500 **there** **were** **printing** **firms** **in** 60 **German** **cities**, **but** **there** **were** 150 **presses** **in** Venice **alone**. **However**, **since** **many** **nations** **and** **governments** **wanted** **their** **own** **presses**, **the** **trade** quickly **became** **international**. **The** cumulative impact **of** **this** industrial **spread** **was** spectacular. **Before** **printing**, **only** **the** **very** largest **libraries**, **of** **which** **there** **were** **a** **dozen** **in** **Europe**, **had** **as** **many** **as** 600 **books**. **The** **total** **number** **of** **books** **on** **the** **entire** **Continent** **was** **well** **under** 100,000. **But** **by** 1500, after **only** 45 **years** **of** **the** **printed** **book**, **there** **were** 9 **million** **in** circulation.

count: 251

# Official 54-Passage 01 The Commercialization of Lumber

**In** nineteenth-**century** **America**, practically **everything** **that** **was** **built** involved **wood**.**Pine** **was** **especially** **attractive** **for** **building** **purposes**.**It** **is** durable **and** **strong**, **yet** **soft** **enough** **to** **be** **easily** worked **with** **even** **the** simplest **of** **hand** **tools**.**It** **also** **floats** nicely **on** **water**, **which** **allowed** **it** **to** **be** **transported** **to** **distant** **markets** **across** **the** **nation**.**The** **central** **and** **northern** **reaches** **of** **the** **Great** **Lakes** **states**—Michigan, Wisconsin, **and** Minnesota—**all** **contained** extensive **pine** **forests** **as** **well** **as** **many** **large** **rivers** **for** **floating** logs **into** **the** **Great** **Lakes**, **from** **where** **they** **were** **transported** **nationwide**.

**By** 1860, **the** **settlement** **of** **the** **American** **West** **along** **with** timber shortages **in** **the** **East** converged **with** **ever**-widening impact **on** **the** **pine** **forests** **of** **the** **Great** **Lakes** **states**. **Over** **the** **next** 30 **years**, lumbering **became** **a** **full**-fledged **enterprise** **in** Michigan, Wisconsin, **and** Minnesota. Newly **formed** lumbering **corporations** **bought** **up** **huge** tracts **of** pineland **and** **set** **about** systematically **cutting** **the** **trees**. **Both** **the** colonists **and** **the** **later** industrialists **saw** timber **as** **a** commodity, **but** **the** **latter** **group** **adopted** **a** **far** **more** **thorough** **and** **calculating** **approach** **to** **removing** **trees**. **In** **this** **sense**, **what** **happened** **between** 1860 **and** 1890 **represented** **a** significant **break** **with** **the** **past**. **No** longer **were** **farmers** **in** **search** **of** **extra** **income** **the** **main** source **for** shingles, **firewood**, **and** **other** **wood** **products**. **By** **the** 1870s, **farmers** **and** **city** dwellers **alike** **purchased** **forest** **products** **from** **large** manufacturing **companies** located **in** **the** **Great** **Lakes** **states** **rather** **than** chopping **wood** **themselves** **or** **buying** **it** locally.

**The** commercialization **of** lumbering **was** **in** **part** **the** **product** **of** technological **change**. **The** **early**, **thick** **saw** blades **tended** **to** **waste** **a** **large** **quantity** **of** **wood**, **with** **perhaps** **as** **much** **as** **a** **third** **of** **the** log **left** **behind** **on** **the** **floor** **as** sawdust **or** scrap. **In** **the** 1870s, **however**, **the British**-**invented** **band** **saw**, **with** **its** thinner blade, **became** **standard** issue **in** **the** **Great** **Lakes** **states**' lumber **factories**.**Meanwhile**, **the** **rise** **of** **steam**-**powered** mills streamlined **production** **by** **allowing** **for** **the** **more** efficient, centralized, **and** continuous **cutting** **of** lumber. **Steam** **helped** **to** automate **a** **variety** **of** **tasks**, **from** **cutting** **to** **the** **carrying** **away** **of** **waste**. Mills **also** **employed** **steam** **to** **heat** log **ponds**, **preventing** **them** **from** **freezing** **and** **making** **possible** **year**-**round** lumber **production**.

**For** industrial lumbering **to** **succeed**, **a** **way** **had** **to** **be** **found** **to** neutralize **the** **effects** **of** **the** **seasons** **on** **production**. Traditionally, **cutting** **took** **place** **in** **the** **winter**, **when** **snow** **and** **ice** **made** **it** easier **to** **drag** logs **on** sleds **or** sleighs **to** **the** **banks** **of** **streams**. **Once** **the** **streams** **and** **lakes** thawed, **workers** rafted **the** logs **to** mills, **where** **they** **were** **cut** **into** lumber **in** **the** **summer**. **If** **nature** **did** **not** cooperate—**if** **the** **winter** **proved** **dry** **and** **warm**, **if** **the** **spring** thaw **was** **delayed**—**production** **would** **suffer**. **To** **counter** **the** **effects** **of** **climate** **on** lumber **production**, loggers **experimented** **with** **a** **variety** **of** **techniques** **for** **transporting** **trees** **out** **of** **the** **woods**. **In** **the** 1870s, loggers **in** **the** **Great** **Lakes** **states** **began** sprinkling **water** **on** sleigh **roads**, **giving** **them** an **artificial** **ice** **coating** **to** facilitate **travel**. **The** **ice** **reduced** **the** **friction** **and** **allowed** **workers** **to** **move** larger **and** heavier **loads**.

**But** **all** **the** sprinkling **in** **the** **world** **would** **not** **save** **a** logger **from** **the** threat **of** **a** **warm** **winter**. **Without** **snow** **the** sleigh **roads** **turned** **to** **mud**. **In** **the** 1870s, **a** **set** **of** snowless **winters** **left** lumber **companies** **to** ponder **ways** **of** **liberating** **themselves** **from** **the** **seasons**. Railroads **were** **one** **possibility**.**At** **first**, **the** remoteness **of** **the** **pine** **forests** **discouraged** **common** **carriers** **from** **laying** **track**.**But** **increasing** lumber **prices** **in** **the** **late** 1870s **combined** **with** periodic **warm**, **dry** **winters** compelled loggers **to** **turn** **to** **iron** **rails**. **By** 1887, 89 logging railroads crisscrossed Michigan, **transforming** logging **from** **a** **winter** **activity** **into** **a** **year**-**round** **one**.

**Once** **the** logs **arrived** **at** **a** **river**, **the** **trip** downstream **to** **a** mill **could** **be** **a** **long** **and** tortuous **one**.Logjams (buildups **of** logs **that** **prevent** logs **from** **moving** downstream) **were** **common**—**at** **times** stretching **for** 10 **miles**—**and** **became** **even** **more** **frequent** **as** **pressure** **on** **the** **northern** Midwest pinelands **increased** **in** **the** 1860s. **To** **help** **keep** **the** logs **moving** efficiently, **barriers** **called** **booms** (essentially **a** **chain** **of** **floating** logs) **were** **constructed** **to** **control** **the** **direction** **of** **the** timber. **By** **the** 1870s, lumber **companies** **existed** **in** **all** **the** **major** logging **areas** **of** **the** **northern** Midwest.

count: 249

# Official 06-Passage 01 Powering the Industrial Revolution

**In** **Britain** **one** **of** **the** **most** dramatic **changes** **of** **the** Industrial **Revolution** **was** **the** harnessing **of** **power**. **Until** **the** reign **of** George III (1760-1820), **available** sources **of** **power** **for** **work** **and** **travel** **had** **not** **increased** **since** **the** **Middle** **Ages**. **There** **were** **three** sources **of** **power**: **animal** **or** **human** muscles; **the** **wind**, **operating** **on** **sail** **or** windmill; **and** **running** **water**. **Only** **the** **last** **of** **these** **was** **suited** **at** **all** **to** **the** continuous **operating** **of** **machines**, **and** **although** waterpower abounded **in** Lancashire **and** **Scotland** **and** **ran** **grain** mills **as** **well** **as** textile mills, **it** **had** **one** **great** **disadvantage**: **streams** **flowed** **where** **nature** **intended** **them** **to**, **and** **water**-**driven** **factories** **had** **to** **be** located **on** **their** **banks**, **whether** **or** **not** **the** location **was** desirable **for** **other** **reasons**. Furthermore, **even** **the** **most** **reliable** waterpower varied **with** **the** **seasons** **and** **disappeared** **in** **a** drought. **The** **new** **age** **of** machinery, **in** **short**, **could** **not** **have** **been** **born** **without** **a** **new** source **of** **both** movable **and** **constant** **power**.

**The** source **had** **long** **been** **known** **but** **not** **exploited**. **Early** **in** **the** **century**, **a** **pump** **had** **come** **into** **use** **in** **which** **expanding** **steam** **raised** **a** piston **in** **a** cylinder, **and** atmospheric **pressure** **brought** **it** **down** **again** **when** **the** **steam** condensed **inside** **the** cylinder **to** **form** **a** vacuum. **This** “atmospheric **engine**,” **invented** **by** Thomas Savery **and** vastly **improved** **by** **his** **partner**, Thomas Newcomen, embodied revolutionary **principles**, **but** **it** **was** **so** **slow** **and** wasteful **of** **fuel** **that** **it** **could** **not** **be** **employed** **outside** **the** **coal** **mines** **for** **which** **it** **had** **been** **designed**. **In** **the** 1760s, James Watt **perfected** **a** **separate** condenser **for** **the** **steam**, **so** **that** **the** cylinder **did** **not** **have** **to** **be** **cooled** **at** **every** stroke; **then** **he** devised **a** **way** **to** **make** **the** piston **turn** **a** **wheel** **and** **thus** convert reciprocating (**back** **and** forth) motion **into** rotary motion. **He** thereby **transformed** an inefficient **pump** **of** **limited** **use** **into** **a** **steam** **engine** **of** **a** **thousand** **uses**. **The** **final** **step** **came** **when** **steam** **was** **introduced** **into** **the** cylinder **to** **drive** **the** piston **backward** **as** **well** **as** **forward**, thereby **increasing** **the** **speed** **of** **the** **engine** **and** **cutting** **its** **fuel** consumption.

Watt’s **steam** **engine** **soon** **showed** **what** **it** **could** **do**. **It** **liberated** **industry** **from** dependence **on** **running** **water**. **The** **engine** eliminated **water** **in** **the** **mines** **by** **driving** efficient **pumps**, **which** **made** **possible** deeper **and** deeper **mining**. **The** **ready** availability **of** **coal** **inspired** William Murdoch **during** **the** 1790s **to** **develop** **the** **first** **new** **form** **of** nighttime illumination **to** **be** **discovered** **in** **a** millennium **and** **a** **half**. **Coal** **gas** rivaled smoky **oil** **lamps** **and** flickering **candles**, **and** **early** **in** **the** **new** **century**, **well**-**to**-**do** Londoners **grew** **accustomed** **to** gaslit **houses** **and** **even** **streets**. **Iron** manufacturers, **which** **had** **starved** **for** **fuel** **while** **depending** **on** charcoal, **also** **benefited** **from** **ever**-**increasing** **supplies** **of** **coal**; blast furnaces **with** **steam**-**powered** bellows **turned** **out** **more** **iron** **and** **steel** **for** **the** **new** machinery. **Steam** **became** **the** motive **force** **of** **the** Industrial **Revolution**, **as** **coal** **and** **iron** ore **were** **the** **raw** **materials**.

**By** 1800 **more** **than** **a** **thousand** **steam** **engines** **were** **in** **use** **in** **the British** Isles, **and** **Britain** retained **a** virtual monopoly **on** **steam** **engine** **production** **until** **the** 1830s. **Steam** **power** **did** **not** **merely** **spin** **cotton** **and** **roll** **iron**; **early** **in** **the** **new** **century**, **it** **also** **multiplied** **ten** **times** **over** **the** **amount** **of** **paper** **that** **a** **single** **worker** **could** **produce** **in** **a** **day**. **At** **the** **same** **time**, **operators** **of** **the** **first** **printing** **presses** **run** **by** **steam** **rather** **than** **by** **hand** **found** **it** **possible** **to** **produce** **a** **thousand** **pages** **in** an **hour** **rather** **than** **thirty**. **Steam** **also** **promised** **to** eliminate **a** transportation **problem** **not** fully solved **by** **either** **canal** **boats** **or** turnpikes. **Boats** **could** **carry** **heavy** **weights**, **but** **canals** **could** **not** **cross** **hilly** terrain; turnpikes **could** **cross** **the** **hills**, **but** **the** roadbeds **could** **not** **stand** **up** **under** **great** **weights**. **These** **problems** **needed** **still** **another** solution, **and** **the** ingredients **for** **it** **lay** **close** **at** **hand**. **In** **some** industrial regions, **heavily** laden wagons, **with** flanged **wheels**, **were** **being** hauled **by** **horses** **along** **metal** **rails**; **and** **the** stationary **steam** **engine** **was** puffing **in** **the** **factory** **and** **mine**. **Another** **generation** **passed** **before** **inventors** **succeeded** **in** **combining** **these** ingredients, **by** **putting** **the** **engine** **on** **wheels** **and** **the** **wheels** **on** **the** **rails**, **so** **as** **to** **provide** **a** **machine** **to** **take** **the** **place** **of** **the** **horse**. **Thus** **the** railroad **age** **sprang** **from** **what** **had** **already** **happened** **in** **the** eighteenth **century**.

count: 248

# Official 29-Passage 03 The History of Waterpower

**Moving** **water** **was** **one** **of** **the** earliest energy sources **to** **be** harnessed **to** **reduce** **the** workload **of** **people** **and** **animals**. **No** **one** **knows** **exactly** **when** **the** waterwheel **was** **invented**, **but** **irrigation** **systems** **existed** **at** **least** 5,000 **years** **ago**, **and** **it** **seems** **probable** **that** **the** earliest waterpower device **was** **the** noria, **a** waterwheel **that** **raised** **water** **for** **irrigation** **in** **attached** **jars**. **This** device **appears** **to** **have** evolved **no** **later** **than** **the** **fifth** **century** B.C., **perhaps** independently **in** **different** regions **of** **the** **Middle** **and** **Far** **East**.

**The** earliest waterpower mills **were** **probably** **vertical**-axis mills **for** grinding **corn**, **known** **as** Norse **or** **Greek** mills, **which** **seem** **to** **have** **appeared** **during** **the** **first** **or** **second** **century** B.C. **in** **the** **Middle East** **East** **and** **a** **few** **centuries** **later** **in** Scandinavia. **In** **the** **following** **centuries**, increasingly sophisticated waterpower mills **were** **built** **throughout** **the** Roman **Empire** **and** **beyond** **its** **boundaries** **in** **the** **Middle East** **East** **and** **northern** **Europe**. **In** **England**, **the** Saxons **are** **thought** **to** **have** **used** **both** horizontal- **and** **vertical**-axis **wheels**. **The** **first** **documented** **English** mill **was** **in** **the** **eighth** **century**, **but** **three** **centuries** **later** **about** 5,000 **were** **recorded**, **suggesting** **that** **every** **settlement** **of** **any** **size** **had** **its** mill.

**Raising** **water** **and** grinding **corn** **were** **by** **no** **means** **the** **only** **uses** **of** **the** waterpower mill, **and** **during** **the** **following** **centuries**, **the** **applications** **of** waterpower **kept** **pace** **with** **the** **developing** **technologies** **of** **mining**, **iron** **working**, **paper** **making**, **and** **the** wool **and** **cotton** **industries**. **Water** **was** **the** **main** source **of** mechanical **power**, **and** **by** **the** **end** **of** **the** seventeenth **century**, **England** **alone** **is** **thought** **to** **have** **had** **some** 20,000 **working** mills.

**There** **was** **much** **debate** **on** **the** **relative** efficiencies **of** **different** **types** **of** waterwheels. **The** **period** **from** **about** 1650 **until** 1800 **saw** **some** **excellent** **scientific** **and** **technical** investigations **of** **different** **designs**. **They** revealed **output** **powers** **ranging** **from** **about** 1 horsepower **to** **perhaps** 60 **for** **the** largest **wheels** **and** **confirmed** **that** **for** **maximum** efficiency, **the** **water** **should** **pass** **across** **the** blades **as** smoothly **as** **possible** **and** **fall** **away** **with** **minimum** **speed**, **having** **given** **up** **almost** **all** **of** **its** kinetic energy. (**They** **also** **proved** **that**, **in** **principle**, **the** overshot **wheel**, **a** **type** **of** **wheel** **in** **which** an **overhead** **stream** **of** **water** **powers** **the** **wheel**, **should** **win** **the** efficiency **competition**.)

**But** **then** **steam** **power** **entered** **the** **scene**, **putting** **the** **whole** **future** **of** waterpower **in** **doubt**. An energy analyst **writing** **in** **the** **year** 1800 **would** **have** **painted** **a** **very** pessimistic **picture** **of** **the** **future** **for** waterpower. **The** **coal**-**fired** **steam** **engine** **was** **taking** **over**, **and** **the** waterwheel **was** **fast** **becoming** obsolete. **However**, **like** **many** **later** **experts**, **this** **one** **would** **have** **suffered** **from** an inability **to** **see** **into** **the** **future**. **A** **century** **later** **the** **picture** **was** completely **different**: **by** **then**, **the** **world** **had** an **electric** **industry**, **and** **a** **quarter** **of** **its** generating capacity **was** **water** **powered**.

**The** **growth** **of** **the** **electric**-**power** **industry** **was** **the** **result** **of** **a** remarkable series **of** **scientific** **discoveries** **and** **developments** **in** electrotechnology **during** **the** nineteenth **century**, **but** significant **changes** **in** **what** **we** **might** **now** **call** hydro (**water**) **technology** **also** **played** **their** **part**. **In** 1832, **the** **year** **of** Michael Faraday’s **discovery** **that** **a** **changing** magnetic **field** **produces** an **electric** **field**, **a** **young** **French** **engineer** **patented** **a** **new** **and** **more** efficient waterwheel. **His** **name** **was** Benoît Fourneyron, **and** **his** device **was** **the** **first** **successful** **water** turbine. (**The** **word** turbine **comes** **from** **the** Latin turbo: **something** **that** **spins**). **The** waterwheel, unaltered **for** **nearly** 2,000 **years**, **had** finally **been** superseded.

**Half** **a** **century** **of** **development** **was** **needed** **before** Faraday’s **discoveries** **in** **electricity** **were** **translated** **into** **full**-scale **power** **stations**. **In** 1881 **the** Godalming **power** **station** **in** Surrey, **England**, **on** **the** **banks** **of** **the** Wey **River**, **created** **the** **world**’s **first** **public** **electricity** **supply**. **The** **power** source **of** **this** **most** **modern** **technology** **was** **a** **traditional** waterwheel. **Unfortunately** **this** **early** **plant** **experienced** **the** **problem** **common** **to** **many** **forms** **of** renewable energy: **the** **flow** **in** **the** Wey **River** **was** unreliable, **and** **the** waterwheel **was** **soon** **replaced** **by** **a** **steam** **engine**.

**From** **this** **primitive** **start**, **the** **electric** **industry** **grew** **during** **the** **final** 20 **years** **of** **the** nineteenth **century** **at** **a** **rate** **seldom** **if** **ever** exceeded **by** **any** **technology**. **The** capacity **of** individual **power** **stations**, **many** **of** **them** hydro **plants**, **rose** **from** **a** **few** kilowatts **to** **over** **a** megawatt **in** **less** **than** **a** **decade**.

count: 247

# Official 46-Passage 01 The Origins of Writing

**It** **was** **in** **Egypt** **and** Mesopotamia (**modern**-**day** Iraq) **that** **civilization** **arose**, **and** **it** **is** **there** **that** **we** **find** **the** earliest **examples** **of** **that** **key** feature **of** **civilization**, **writing**. **These** **examples**, **in** **the** **form** **of** inscribed **clay** **tablets** **that** **date** **to** **shortly** **before** 3000 B.C.E., **have** **been** **discovered** **among** **the** archaeological **remains** **of** **the** Sumerians, **a** **gifted** **people** **settled** **in** **southern** Mesopotamia.

**The** **Egyptians** **were** **not** **far** **behind** **in** **developing** **writing**, **but** **we** cannot **follow** **the** **history** **of** **their** **writing** **in** detail **because** **they** **used** **a** perishable **writing** **material**. **In** **ancient** **times** **the** **banks** **of** **the** Nile **were** **lined** **with** papyrus **plants**, **and** **from** **the** papyrus reeds **the** **Egyptians** **made** **a** **form** **of** **paper**; **it** **was** **excellent** **in** **quality** **but**, **like** **any** **paper**, **fragile**. Mesopotamia’s **rivers** boasted **no** **such** **useful** reeds, **but** **its** **land** **did** **provide** **good** **clay**, **and** **as** **a** **consequence** **the** **clay** **tablet** **became** **the** **standard** **material**. **Though** **clumsy** **and** bulky **it** **has** **a** **virtue** **dear** **to** archaeologists: **it** **is** durable. **Fire**, **for** **example**, **which** **is** **death** **to** papyrus **paper** **or** **other** **writing** **materials** **such** **as** **leather** **and** **wood**, **simply** **bakes** **it** **hard**, thereby **making** **it** **even** **more** durable. **So** **when** **a** conqueror **set** **a** Mesopotamian **palace** ablaze, **he** **helped** ensure **the** **survival** **of** **any** **clay** **tablets** **in** **it**. **Clay**, moreover, **is** **cheap**, **and** **forming** **it** **into** **tablets** **is** **easy**, factors **that** **helped** **the** **clay** **tablet** **become** **the** **preferred** **writing** **material** **not** **only** **throughout** Mesopotamia **but** **far** **outside** **it** **as** **well**, **in** Syria, **Asia** Minor, Persia, **and** **even** **for** **a** **while** **in** Crete **and** **Greece**. Excavators **have** unearthed **clay** **tablets** **in** **all** **these** **lands**. **In** **the** **Near** **East** **they** **remained** **in** **use** **for** **more** **than** **two** **and** **a** **half** millennia, **and** **in** **certain** **areas** **they** **lasted** **down** **to** **the** **beginning** **of** **the** **common** era **until** finally yielding, **once** **and** **for** **all**, **to** **more** **convenient** **alternatives**.

**The** Sumerians **perfected** **a** **style** **of** **writing** **suited** **to** **clay**. **This** script **consists** **of** **simple** **shapes**, basically **just** wedge **shapes** **and** **lines** **that** **could** **easily** **be** incised **in** **soft** **clay** **with** **a** reed **or** **wooden** stylus; **scholars** **have** dubbed **it** cuneiform **from** **the** wedge-**shaped** **marks** (cunei **in** Latin) **that** **are** **its** hallmark. **Although** **the** ingredients **are** **merely** wedges **and** **lines**, **there** **are** **hundreds** **of** combinations **of** **these** **basic** **forms** **that** **stand** **for** **different** **sounds** **or** **words**. **Learning** **these** **complex** **signs** **required** **long** **training** **and** **much** **practice**; inevitably, literacy **was** largely **limited** **to** **a** **small** professional **class**, **the** scribes.

**The** Akkadians conquered **the** Sumerians **around** **the** **middle** **of** **the** **third** millennium B.C.E., **and** **they** **took** **over** **the** **various** cuneiform **signs** **used** **for** **writing** Sumerian **and** **gave** **them** **sound** **and** **word** **values** **that** **fit** **their** **own** **language**. **The** Babylonians **and** Assyrians **did** **the** **same**, **and** **so** **did** **peoples** **in** Syria **and** **Asia** Minor. **The** **literature** **of** **the** Sumerians **was** **treasured** **throughout** **the** **Near** **East**, **and** **long** after Sumerian ceased **to** **be** **spoken**, **the** Babylonians **and** Assyrians **and** **others** **kept** **it** **alive** **as** **a** **literary** **language**, **the** **way** Europeans **kept** Latin **alive** after **the** **fall** **of** Rome. **For** **the** scribes **of** **these** non-Sumerian **languages**, **training** **was** doubly **demanding** **since** **they** **had** **to** **know** **the** **values** **of** **the** **various** cuneiform **signs** **for** Sumerian **as** **well** **as** **for** **their** **own** **language**.

**The** **contents** **of** **the** earliest **clay** **tablets** **are** **simple** notations **of** **numbers** **of** commodities—**animals**, **jars**, **baskets**, etc. **Writing**, **it** **would** **appear**, **started** **as** **a** **primitive** **form** **of** bookkeeping. **Its** **use** **soon** widened **to** **document** **the** multitudinous **things** **and** **acts** **that** **are** involved **in** **daily** **life**, **from** **simple** inventories **of** commodities **to** complicated governmental **rules** **and** **regulations**.

    Archaeologists frequently **find** **clay** **tablets** **in** batches. **The** batches, **some** **of** **which** **contain** **thousands** **of** **tablets**, **consist** **for** **the** **most** **part** **of** **documents** **of** **the** **types** **just** **mentioned**: **bills**, deliveries, **receipts**, inventories, loans, **marriage** contracts, **divorce** **settlements**, **court** judgments, **and** **so** **on**. **These** **records** **of** factual **matters** **were** **kept** **in** **storage** **to** **be** **available** **for** **reference**—**they** **were**, **in** **effect**, **files**, **or**, **to** **use** **the** **term** **preferred** **by** **specialists** **in** **the** **ancient** **Near** **East**, archives. **Now** **and** **then** **these** **files** **include** **pieces** **of** **writing** **that** **are** **of** **a** distinctly **different** **order**, **writings** **that** **do** **not** **merely** **record** **some** **matter** **of** **fact** **but** involve creative intellectual **activity**. **They** **range** **from** **simple** **textbook** **material** **to** **literature**—**and** **they** **make** an **appearance** **very** **early**, **even** **from** **the** **third** millennium B.C.E.

count: 245

# Official 53-Passage 03 Paleolithic Cave Paintings

**In** **any** investigation **of** **the** **origins** **of** **art**, **attention** **focuses** **on** **the** **cave** **paintings** **created** **in** **Europe** **during** **the** Paleolithic era (C. 40,000-10,000 **years** **ago**) **such** **as** **those** depicting bulls **and** **other** **animals** **in** **the** Lascaux **cave** **in** **France**. **Accepting** **that** **they** **are** **the** **best** **preserved** **and** **most** visible **signs** **of** **what** **was** **a** global creative explosion, **how** **do** **we** **start** **to** **explain** **their** **appearance**? Instinctively, **we** may **want** **to** update **the** earliest **human** **artists** **by** **assuming** **that** **they** **painted** **for** **the** sheer **joy** **of** **painting**. **The** philosophers **of** **Classical** **Greece** recognized **it** **as** **a** defining trait **of** **humans** **to** “**delight** **in** **works** **of** imitation”—**to** **enjoy** **the** **very** **act** **and** triumph **of** representation. **If** **we** **were** **close** **to** **a** **real** **lion** **or** **snake**, **we** **might** **feel** **frightened**. **But** **a** **well**-executed **picture** **of** **a** **lion** **or** **snake** **will** **give** us **pleasure**. **Why** **suppose** **that** **our** Paleolithic **ancestors** **were** **any** **different**?

**This** **simple** acceptance **of** **art** **for** **art**’s sake **has** **a** **certain** **appeal**. **To** **think** **of** Lascaux **as** **a** **gallery** **allows** **it** **to** **be** **a** **sort** **of** **special** **viewing** **place** **where** **the** handiwork **of** **accomplished** **artists** **might** **be** displayed. Plausibly, **daily** **existence** **in** **parts** **of** Paleolithic **Europe** may **not** **have** **been** **so** **hard**, **with** an abundance **of** **ready** **food** **and** **therefore** **the** leisure **time** **for** **art**. **The** **problems** **with** **this** **explanation**, **however**, **are** **various**. **In** **the** **first** **place**, **the** proliferation **of** archaeological **discoveries**—**and** **this** **includes** **some** **of** **the** **world**’s innumerable **rock** **art** sites **that** cannot **be** **dated**—**has** **served** **to** emphasize **a** remarkably **limited** repertoire **of** **subjects**. **The** images **that** recur **are** **those** **of** **animals**. **Human** **figures** **are** **unusual**, **and** **when** **they** **do** **make** an **appearance**, **they** **are** rarely **done** **with** **the** **same** **attention** **to** **form** accorded **to** **the** **animals**. **If** Paleolithic **artists** **were** **simply** **seeking** **to** **represent** **the** **beauty** **of** **the** **world** **around** **them**, **would** **they** **not** **have** **left** **a** **far** greater **range** **of** **pictures**—**of** **trees**, **flowers**, **of** **the** **Sun** **and** **the** **stars**?

**A** further **question** **to** **the** **theory** **of** **art** **for** **art**’s sake **is** posed **by** **the** **high** incidence **of** Paleolithic images **that** **appear** **not** **to** **be** imitative **of** **any** **reality** whatsoever. **These** **are** geometrical **shapes** **or** **patterns** **consisting** **of** **dots** **or** **lines**. **Such** **marks** may **be** **found** isolated **or** **repeated** **over** **a** **particular** **surface**, **but** **also** scattered **across** **more** recognizable **forms**. **A** **good** **example** **of** **this** may **be** **seen** **in** **the** geologically spectacular grotto **of** Pêche Merle, **in** **the** **Lot** region **of** **France**. **Here** **we** encounter **some** favorite **animals** **from** **the** Paleolithic repertoire—**a** **pair** **of** **stout**-**bellied** **horses**. **But** **over** **and** **around** **the** **horses**’ **outlines** **are** multiple **dark** **spots**, daubed **in** disregard **for** **the** **otherwise** naturalistic representation **of** **animals**. **What** **does** **such** **patterning** imitate? **There** **is** **also** **the** factor **of** location. **The** **caves** **of** Lascaux **might** conceivably qualify **as** **underground** **galleries**, **but** **many** **other** **paintings** **have** **been** **found** **in** recesses **totally** unsuitable **for** **any** **kind** **of** **viewing**—**tight** nooks **and** crannies **that** must **have** **been** **awkward** **even** **for** **the** **artists** **to** penetrate, **let** **alone** **for** **anyone** **else** **wanting** **to** **see** **the** **art**.

Finally, **we** may **doubt** **the** notion **that** **the** **Upper** Paleolithic **period** **was** **a** paradise **in** **which** **food** **came** readily, **leaving** **humans** **ample** **time** **to** **amuse** **themselves** **with** **art**. **For** **Europe** **it** **was** **still** **the** **Ice** **Age**. An estimate **of** **the** **basic** **level** **of** sustenance **then** **necessary** **for** **human** **survival** **has** **been** **judged** **at** 2200 calories **per** **day**. **This** **consideration**, **combined** **with** **the** stark emphasis **upon** **animals** **in** **the** **cave** **art**, **has** **persuaded** **some** archaeologists **that** **the** **primary** motive **behind** Paleolithic images must **lie** **with** **the** **primary** **activity** **of** Paleolithic **people**: **hunting**.

**Hunting** **is** **a** **skill**. **Tracking**, stalking, chasing, **and** **killing** **the** prey **are** **difficult**, **sometimes** **dangerous** **activities**. **What** **if** **the** **process** **could** **be** **made** easier—**by** **art**? **In** **the** **early** **decades** **of** **the** **twentieth** **century**, Abbé Henri Breuil **argued** **that** **the** **cave** **paintings** **were** **all** **about** “sympathetic **magic**.” **The** **artists** strived diligently **to** **make** **their** **animal** images evocative **and** realistic **because** **they** **were** **attempting** **to** capture **the** **spirit** **of** **their** prey. **What** **could** **have** prompted **their** studious **attention** **to** **making** **such** naturalistic, recognizable images? **According to** Breuil, **the** **artists** may **have** **believed** **that** **if** **a** **hunter** **were** **able** **to** **make** **a** **true** likeness **of** **some** **animal**, **then** **that** **animal** **was** virtually **trapped**. Images, **therefore**, may **have** **had** **the** magical capacity **to** confer **success** **or** **luck** **in** **the** **hunt**.

count: 244

# Official 46-Passage 02 The Commercial Revolution in Medieval Europe

**Beginning** **in** **the** 1160s, **the** **opening** **of** **new** **silver** **mines** **in** **northern** **Europe** **led** **to** **the** minting **and** circulation **of** **vast** **quantities** **of** **silver** **coins**. **The** **widespread** **use** **of** **cash** greatly **increased** **the** volume **of** **international** **trade**. **Business** **procedures** **changed** radically. **The** individual traveling **merchant** **who** **alone** **handled** virtually **all** **aspects** **of** **exchange** evolved **into** an **operation** involving **three** **separate** **types** **of** **merchants**: **the** sedentary **merchant** **who** **ran** **the** “**home** **office**,” **financing** **and** organizing **the** **firm**’s **entire** **export**-**import** **trade**; **the** **carriers** **who** **transported** **goods** **by** **land** **and** **sea**; **and** **the** **company** **agents** resident **in** **cities** **abroad** **who**, **on** **the** **advice** **of** **the** **home** **office**, **looked** after **sales** **and** procurements.

    Commercial correspondence, unnecessary **when** **one** businessperson oversaw **everything** **and** **made** **direct** **bargains** **with** buyers **and** sellers, **multiplied**. **Regular** courier **service** **among** commercial **cities** **began**. Commercial **accounting** **became** **more** **complex** **when** **firms** **had** **to** **deal** **with** shareholders, manufacturers, **customers**, **branch** **offices**, employees, **and** **competing** **firms**. Tolls **on** **roads** **became** **high** **enough** **to** **finance** **what** **has** **been** **called** **a** **road** **revolution**, involving **new** **surfaces** **and** **bridges**, **new** **passes** **through** **the** Alps, **and** **new** **inns** **and** hospices **for** **travelers**. **The** **growth** **of** mutual **trust** **among** **merchants** facilitated **the** **growth** **of** **sales** **on** **credit** **and** **led** **to** **new** **developments** **in** **finance**, **such** **as** **the** **bill** **of** **exchange**, **a** device **that** **made** **the** **long**, **slow**, **and** **very** **dangerous** shipment **of** **coins** unnecessary.

**The** ventures **of** **the** **German** Hanseatic **League** illustrate **these** advancements. **The** Hanseatic **League** **was** **a** mercantile **association** **of** **European** **towns** **dating** **from** 1159. **The** **league** **grew** **by** **the** **end** **of** **the** fourteenth **century** **to** **include** **about** 200 **cities** **from** Holland **to** Poland. **Across** **regular**, **well**-defined **trade** routes **along** **the** Baltic **and** **North** **seas**, **the** **ships** **of** **league** **cities** **carried** **furs**, **wax**, copper, **fish**, **grain**, timber, **and** **wine**. **These** **goods** **were** **exchanged** **for** **finished** **products**, mainly **cloth** **and** **salt**, **from** **western** **cities**. **At** **cities** **such** **as** Bruges **and** **London**, Hanseatic **merchants** **secured** **special** **trading** concessions, exempting **them** **from** **all** tolls **and** **allowing** **them** **to** **trade** **at** **local** **fairs**. Hanseatic **merchants** established **foreign** **trading** centers, **the** **most** **famous** **of** **which** **was** **the** **London** Steelyard, **a** **walled** community **with** **warehouses**, **offices**, **a** **church**, **and** residential **quarters** **for** **company** **representatives**. **By** **the** **late** thirteenth **century**, Hanseatic **merchants** **had** **developed** an **important** **business** **technique**, **the** **business** **register**. **Merchants** **publicly** **recorded** **their** **debts** **and** contracts **and** **received** **a** **league** **guarantee** **for** **them**. **This** device **proved** **a** decisive factor **in** **the** **later** **development** **of** **credit** **and** commerce **in** **northern** **Europe**.

**These** **developments** **added** **up** **to** **what** **one** **modern** **scholar** **has** **called** “**a** commercial **revolution**.” **In** **the** **long** **run**, **the** commercial **revolution** **of** **the** **High** **Middle** **Ages** (**A**.D. 1000–1300) **brought** **about** radical **change** **in** **European** **society**. **One** remarkable **aspect** **of** **this** **change** **was** **that** **the** commercial **classes** constituted **a** **small** **part** **of** **the** **total** **population**—**never** **more** **than** 10 **percent**. **They** **exercised** an **influence** **far** **in** excess **of** **their** **numbers**. **The** commercial **revolution** **created** **a** **great** **deal** **of** **new** **wealth**, **which** **meant** **a** higher **standard** **of** **living**. **The** **existence** **of** **wealth** **did** **not** **escape** **the** **attention** **of** **kings** **and** **other** **rulers**. **Wealth** **could** **be** **taxed**, **and** **through** taxation, **kings** **could** **create** **strong** **and** centralized **states**. **In** **the** **years** **to** **come**, alliances **with** **the** **middle** **classes** **were** **to** enable **kings** **to** weaken aristocratic **interests** **and** **build** **the** **states** **that** **came** **to** **be** **called** **modern**.

**The** commercial **revolution** **also** **provided** **the** opportunity **for** **thousands** **of** **agricultural** **workers** **to** **improve** **their** **social** **position**. **The** **slow** **but** **steady** transformation **of** **European** **society** **from** **almost** completely rural **and** isolated **to** relatively **more** **urban** constituted **the** greatest **effect** **of** **the** commercial **revolution** **that** **began** **in** **the** eleventh **century**. **Even** **so**, **merchants** **and** **business** **people** **did** **not** **run** medieval communities, **except** **in** **central** **and** **northern** **Italy** **and** **in** **the** county **of** Flanders. **Most** **towns** **remained** **small**. **The** nobility **and** churchmen **determined** **the** predominant **social** **attitudes**, **values**, **and** **patterns** **of** **thought** **and** behavior. **The** commercial **changes** **of** **the** eleventh **through** fourteenth **centuries** **did**, **however**, **lay** **the** economic foundation **for** **the** **development** **of** **urban** **life** **and** **culture**.

count: 244

# Official 32-Passage 02 Siam, 1851 – 1910

**In** **the** **late** nineteenth **century**, **political** **and** **social** **changes** **were** **occurring** rapidly **in** Siam (**now** Thailand). **The** **old** **ruling** **families** **were** **being** displaced **by** an evolving centralized **government**. **These** **families** **were** **pensioned** **off** (**given** **a** sum **of** **money** **to** **live** **on**) **or** **simply** **had** **their** revenues **taken** **away** **or** **restricted**; **their** **sons** **were** enticed **away** **to** **schools** **for** **district** **officers**, **later** **to** **be** **posted** **in** **some** faraway **province**; **and** **the** **old** patron-client **relations** **that** **had** **bound** **together** **local** **societies** **simply** disintegrated. **Local** **rulers** **could** **no** longer **protect** **their** **relatives** **and** attendants **in** **legal** **cases**, **and** **with** **the** **ending** **in** 1905 **of** **the** **practice** **of** **forcing** **peasant** **farmers** **to** **work** **part-time** **for** **local** **rulers**, **the** **rulers** **no** longer **had** **a** **regular** **base** **for** **relations** **with** rural **populations**. **The** **old** **local** **ruling** **families**, **then**, **were** severed **from** **their** **traditional** **social** context.

**The** **same** **situation** **viewed** **from** **the** perspective **of** **the** rural **population** **is** **even** **more** **complex**. **According to** **the** **government**’s **first** census **of** **the** rural **population**, **taken** **in** 1905, **there** **were** **about** **thirty** **thousand** **villages** **in** Siam. **This** **was** **probably** **a** **large** **increase** **over** **the** **figure** **even** **two** **or** **three** **decades** earlier, **during** **the** **late** 1800s. **It** **is** **difficult** **to** **imagine** **it** **now**, **but** Siam’s **Central** **Plain** **in** **the** **late** 1800s **was** **nowhere** **near** **as** densely **settled** **as** **it** **is** **today**. **There** **were** **still** **forests** closely **surrounding** Bangkok **into** **the** **last** **half** **of** **the** nineteenth **century**, **and** **even** **at** **century**’s **end** **there** **were** **wild** **elephants** **and** **tigers** roaming **the** **countryside** **only** **twenty** **or** **thirty** **miles** **away**.

**Much** **population** **movement** involved **the** **opening** **up** **of** **new** **lands** **for** **rice** cultivation. **Two** **things** **made** **this** **possible** **and** **encouraged** **it** **to** **happen**. **First**, **the** **opening** **of** **the** **kingdom** **to** **the** **full** **force** **of** **international** **trade** **by** **the** Bowring Treaty (1855) rapidly **encouraged** economic specialization **in** **the** **growing** **of** **rice**, mainly **to** **feed** **the** **rice**-deficient portions **of** **Asia** (**India** **and** **China** **in** **particular**). **The** **average** **annual** volume **of** **rice** **exported** **from** Siam **grew** **from** **under** 60 **million** **kilograms** **per** **year** **in** **the** **late** 1850s **to** **more** **than** 660 **million** **kilograms** **per** **year** **at** **the** **turn** **of** **the** **century**; **and** **over** **the** **same** **period** **the** **average** **price** **per** **kilogram** **doubled**. **During** **the** **same** **period**, **the** **area** **planted** **in** **rice** **increased** **from** **about** 230,000 **acres** **to** **more** **than** 350,000 **acres**. **This** **growth** **was** **achieved** **as** **the** **result** **of** **the** collective **decisions** **of** **thousands** **of** **peasant** **families** **to** **expand** **the** **amount** **of** **land** **they** cultivated, **clear** **and** **plant** **new** **land**, **or** **adopt** **more** intensive **methods** **of** **agriculture**.

**They** **were** **able** **to** **do** **so** **because** **of** **our** **second** **consideration**. **They** **were** relatively freer **than** **they** **had** **been** **half** **a** **century** earlier. **Over** **the** **course** **of** **the** **Fifth** Reign (1868–1910), **the** **ties** **that** **bound** rural **people** **to** **the** aristocracy **and** **local** **ruling** elites **were** greatly **reduced**. **Peasants** **now** **paid** **a** **tax** **on** individuals **instead** **of** **being** **required** **to** render labor **service** **to** **the** **government**. **Under** **these** **conditions**, **it** **made** **good** **sense** **to** **thousands** **of** **peasant** **families** **to** **in** **effect** **work** **full**-**time** **at** **what** **they** **had** **been** **able** **to** **do** **only** **part-time** previously **because** **of** **the** **requirement** **to** **work** **for** **the** **government**: **grow** **rice** **for** **the** marketplace.

Numerous **changes** **accompanied** **these** **developments**. **The** rural **population** **both** dispersed **and** **grew**, **and** **was** **probably** **less** homogeneous **and** **more** **mobile** **than** **it** **had** **been** **a** **generation** earlier. **The** **villages** **became** **more** vulnerable **to** **arbitrary** **treatment** **by** **government** bureaucrats **as** **local** elites **now** **had** **less** **control** **over** **them**. **By** **the** **early** **twentieth** **century**, **as** **government** modernization **in** **a** **sense** **caught** **up** **with** **what** **had** **been** **happening** **in** **the** **countryside** **since** **the** 1870s, **the** **government** bureaucracy intruded **more** **and** **more** **into** **village** **life**. Provincial **police** **began** **to** **appear**, **along** **with** **district** **officers** **and** **cattle** registration **and** **land** **deeds** **and** registration **for** **compulsory** military **service**. **Village** handicrafts diminished **or** **died** **out** completely **as** **people** **bought** **imported** consumer **goods**, **like** **cloth** **and** **tools**, **instead** **of** **making** **them** **themselves**. **More** economic variation **took** **shape** **in** rural **villages**, **as** **some** **grew** prosperous **from** **farming** **while** **others** **did** **not**. **As** **well** **as** **can** **be** **measured**, rural **standards** **of** **living** **improved** **in** **the** **Fifth** Reign. **But** **the** statistical **averages** **mean** **little** **when** **measured** **against** **the** harsh **realities** **of** **peasant** **life**.

count: 243

# Official 39-Passage 01 Early Writing Systems

**Scholars** **agree** **that** **writing** originated **somewhere** **in** **the** **Middle East** **East**, **probably** Mesopotamia, **around** **the** **fourth** millennium B.C.E. **It** **is** **from** **the** **great** **libraries** **and** **word**-hoards **of** **these** **ancient** **lands** **that** **the** **first** **texts** emerged. **They** **were** **written** **on** **damp** **clay** **tablets** **with** **a** wedged (**or** V-**shaped**) **stick**; **since** **the** Latin **word** **for** wedge **is** cunea, **the** **texts** **are** **called** cuneiform. **The** **clay** **tablets** **usually** **were** **not** **fired**; **sun** **drying** **was** **probably** reckoned **enough** **to** **preserve** **the** **text** **for** **as** **long** **as** **it** **was** **being** **used**. Fortunately, **however**, **many** **tablets** **survived** **because** **they** **were** accidentally **fired** **when** **the** **buildings** **they** **were** **stored** **in** **burned**.

Cuneiform **writing** **lasted** **for** **some** 3,000 **years**, **in** **a** **vast** **line** **of** succession **that** **ran** **through** Sumer, Akkad, Assyria, Nineveh, **and** Babylon, **and** **preserved** **for** us **fifteen** **languages** **in** an **area** **represented** **by** **modern**-**day** Iraq, Syria, **and** **western** Iran. **The** oldest cuneiform **texts** **recorded** **the** transactions **of** **tax** collectors **and** **merchants**, **the** **receipts** **and** **bills** **of** **sale** **of** an **urban** **society**. **They** **had** **to** **do** **with** **things** **like** **grain**, **goats**, **and** **real** estate. **Later**, Babylonian scribes **recorded** **the** **laws** **and** **kept** **other** **kinds** **of** **records**. **Knowledge** conferred **power**. **As** **a** **result**, **the** scribes **were** assigned **their** **own** goddess, Nisaba, **later** **replaced** **by** **the** **god** Nabu **of** Borsippa, **whose** **symbol** **is** **neither** weapon **nor** dragon **but** **something** **far** **more** fearsome, **the** cuneiform **stick**.

Cuneiform **texts** **on** **science**, **astronomy**, **medicine**, **and** **mathematics** abound, **some** **offering** astoundingly **precise** **data**. **One** **tablet** **records** **the** **speed** **of** **the** **Moon** **over** 248 **days**; **another** **documents** an **early** **sighting** **of** Halley’s Comet, **from** **September** 22 **to** **September** 28, 164 B.C.E. **More** esoteric **texts** **attempt** **to** **explain** **old** Babylonian **customs**, **such** **as** **the** **procedure** **for** **curing** **someone** **who** **is** **ill**, **which** **included** rubbing tar **and** gypsum **on** **the** **sick** **person**’s **door** **and** **drawing** **a** **design** **at** **the** **foot** **of** **the** **person**’s **bed**. **What** **is** **clear** **from** **the** **vast** body **of** **texts** (**some** 20,000 **tablets** **were** **found** **in** **King** Ashurbanipal’s **library** **at** Nineveh) **is** **that** scribes **took** **pride** **in** **their** **writing** **and** **knowledge**.

**The** foremost cuneiform **text**, **the** Babylonian Epic **of** Gilgamesh, **deals** **with** humankind’s **attempts** **to** conquer **time**. **In** **it**, Gilgamesh, **king** **and** warrior, **is** crushed **by** **the** **death** **of** **his** **best** **friend** **and** **so** **sets** **out** **on** **adventures** **that** prefigure mythical **heroes** **of** **ancient** **Greek** legends **such** **as** Hercules. **His** **goal** **is** **not** **just** **to** **survive** **his** ordeals **but** **to** **make** **sense** **of** **this** **life**. Remarkably, **versions** **of** Gilgamesh span 1,500 **years**, **between** 2100 B.C.E **and** 600 B.C.E., **making** **the** **story** **the** epic **of** an **entire** **civilization**.

**The** **ancient** **Egyptians** **invented** **a** **different** **way** **of** **writing** **and** **a** **new** substance **to** **write** **on**—papyrus, **a** precursor **of** **paper**, **made** **from** **a** wetland **plant**. **The** Greeks **had** **a** **special** **name** **for** **this** **writing**: hiero glyphic, literally “**sacred** **writing**.” **This**, **they** **thought**, **was** **language** **fit** **for** **the** **gods**, **which** **explains** **why** **it** **was** **carved** **on** **walls** **of** **pyramids** **and** **other** **religious** structures. **Perhaps** hieroglyphics **are** **Egypt**’s **great** **contribution** **to** **the** **history** **of** **writing**: hieroglyphic **writing**, **in** **use** **from** 3100 B.C.E. **until** 394 C.E., **resulted** **in** **the** creation **of** **texts** **that** **were** **fine** **art** **as** **well** **as** **communication**. **Egypt** **gave** us **the** **tradition** **of** **the** scribe **not** **just** **as** **educated** **person** **but** **as** **artist** **and** calligrapher.

**Scholars** **have** detected **some** 6,000 **separate** hieroglyphic **characters** **in** **use** **over** **the** **history** **of** **Egyptian** **writing**, **but** **it** **appears** **that** **never** **more** **than** **a** **thousand** **were** **in** **use** **during** **any** **one** **period**. **It** **still** **seems** **a** **lot** **to** recall, **but** **what** **was** **lost** **in** efficiency **was** **more** **than** **made** **up** **for** **in** **the** **beauty** **and** richness **of** **the** **texts**. **Writing** **was** **meant** **to** **impress** **the** **eye** **with** **the** vastness **of** creation **itself**. **Each** **symbol** **or** glyph—**the** **flowering** reed (**pronounced** **like** “i”), **the** owl (“m”), **the** quail **chick** (“w”), etcetera—**was** **a** **tiny** **work** **of** **art**. Manuscripts **were** compiled **with** an **eye** **to** **the** overall **design**. Egyptologists **have** **noticed** **that** **the** glyphs **that** constitute individual **words** **were** **sometimes** shuffled **to** **make** **the** **text** **more** **pleasing** **to** **the** **eye** **with** **little** **regard** **for** **sound** **or** **sense**.

count: 243

# Official 51-Passage 03 Population Growth In Nineteenth-Century Europe

**Because** **of** industrialization, **but** **also** **because** **of** **a** **vast** **increase** **in** **agricultural** **output** **without** **which** industrialization **would** **have** **been** **impossible**, **Western** Europeans **by** **the** **latter** **half** **of** **the** nineteenth **century** **enjoyed** higher **standards** **of** **living** **and** longer, healthier **lives** **than** **most** **of** **the** **world**’s **peoples**. **In** **Europe** **as** **a** **whole**, **the** **population** **rose** **from** 188 **million** **in** 1800 **to** 400 **million** **in** 1900. **By** 1900, virtually **every** **area** **of** **Europe** **had** **contributed** **to** **the** tremendous surge **of** **population**, **but** **each** **major** region **was** **at** **a** **different** **stage** **of** demographic **change**.

Improvements **in** **the** **food** **supply** **continued** **trends** **that** **had** **started** **in** **the** **late** seventeenth **century**. **New** **lands** **were** **put** **under** cultivation, **while** **the** **use** **of** **crops** **of** **American** **origin**, particularly **the** **potato**, **continued** **to** **expand**. Setbacks **did** **occur**. Regional **agricultural** **failures** **were** **the** **most** **common** **cause** **of** economic recessions **until** 1850, **and** **they** **could** **lead** **to** localized famine **as** **well**. **A** **major** **potato** blight (**disease**) **in** 1846-1847 **led** **to** **the** **deaths** **of** **at** **least** **one** **million** **persons** **in** **Ireland** **and** **the** emigration **of** **another** **million**, **and** **Ireland** **never** **recovered** **the** **population** **levels** **the** **potato** **had** sustained **to** **that** **point**. **Bad** **grain** **harvests** **at** **the** **same** **time** **led** **to** **increased** **hardship** **throughout** **much** **of** **Europe**.

After 1850, **however**, **the** expansion **of** **foods** **more** regularly **kept** **pace** **with** **population** **growth**, **though** **the** poorer **classes** **remained** malnourished. **Two** **developments** **were** crucial. **First**, **the** **application** **of** **science** **and** **new** **technology** **to** **agriculture** **increased**. **Led** **by** **German** **universities**, **increasing** **research** **was** **devoted** **to** **improving** **seeds**, **developing** **chemical** fertilizers, **and** **advancing** livestock. After 1861, **with** **the** **development** **of** **land**-grant **universities** **in** **the** **United** **States** **that** **had** **huge** **agricultural** programs, **American** **crop**-**production** **research** **added** **to** **this** **mix**. Mechanization **included** **the** **use** **of** **horse**-**drawn** harvesters **and** **seed** **drills**, **many** **developed** initially **in** **the** **United** **States**. **It** **also** **included** mechanical **cream** separators **and** **other** **food**-**processing** devices **that** **improved** **supply**.

**The** **second** **development** involved industrially **based** transportation. **With** **trains** **and** **steam** **shipping**, **it** **became** **possible** **to** **move** **foods** **to** needy regions **within** **Western** **Europe** quickly. Famine (**as** **opposed** **to** malnutrition) **became** **a** **thing** **of** **the** **past**. **Many** **Western** **European** **countries**, **headed** **by** **Britain**, **began** **also** **to** **import** **increasing** **amounts** **of** **food**, **not** **only** **from** **Eastern** **Europe**, **a** **traditional** source, **but** **also** **from** **the** Americas, **Australia**, **and** **New Zealand** Zealand. **Steam** **shipping**, **which** **improved** **speed** **and** capacity, **as** **well** **as** **new** **procedures** **for** **canning** **and** refrigerating **foods** (particularly after 1870), **was** **fundamental** **to** **these** **developments**.

**Europe**’s **population** **growth** **included** **one** additional innovation **by** **the** nineteenth **century**: **it** **combined** **with** **rapid** urbanization. **More** **and** **more** **Western** Europeans **moved** **from** **countryside** **to** **city**, **and** **big** **cities** **grew** **most** rapidly **of** **all**. **By** 1850, **over** **half** **of** **all** **the** **people** **in** **England** **lived** **in** **cities**, **a** **first** **in** **human** **history**. **In** **one** **sense**, **this** **pattern** **seems** inevitable: **growing** **numbers** **of** **people** **pressed** **available** resources **on** **the** **land**, **even** **when** farmwork **was** **combined** **with** **a** **bit** **of** manufacturing, **so** **people** **crowded** **into** **cities** **seeking** **work** **or** **other** resources. Traditionally, **however**, **death** **rates** **in** **cities** surpassed **those** **in** **the** **countryside** **by** **a** **large** margin; **cities** **had** maintained **population** **only** **through** **steady** **in**-migration. **Thus** **rapid** urbanization **should** **have** **reduced** overall **population** **growth**, **but** **by** **the** **middle** **of** **the** nineteenth **century** **this** **was** **no** longer **the** **case**. **Urban** **death** **rates** **remained** **high**, particularly **in** **the** lower-**class** slums, **but** **they** **began** **to** **decline** rapidly.

**The** greater reliability **of** **food** **supplies** **was** **a** factor **in** **the** **decline** **of** **urban** **death** **rates**. **Even** **more** **important** **were** **the** **gains** **in** **urban** sanitation, **as** **well** **as** **measures** **such** **as** inspection **of** **housing**. Reformers, **including** enlightened **doctors**, **began** **to** **study** **the** **causes** **of** **high** **death** **rates** **and** **to** **urge** remediation. **Even** **before** **the** **discovery** **of** germs, **beliefs** **that** **disease** **spread** **by** “miasmas” (noxious **forms** **of** **bad** **air**) prompted **attention** **to** sewers **and** **open** **garbage**; Edwin Chadwick **led** an exemplary **urban** crusade **for** **underground** sewers **in** **England** **in** **the** 1830s. **Gradually**, **public** **health** provisions **began** **to** **cut** **into** customary **urban** mortality **rates**. **By** 1900, **in** **some** **parts** **of** **Western** **Europe** **life** expectancy **in** **the** **cities** **began** **to** surpass **that** **of** **the** rural **areas**. Industrial **societies** **had** **figured** **out** **ways** **to** **combine** **large** **and** **growing** **cities** **with** **population** **growth**, **a** **development** **that** **would** **soon** **spread** **to** **other** **parts** **of** **the** **world**.

count: 243

# Official 28-Passage 02 Early Saharan Pastoralists

**The** Sahara **is** **a** highly **diverse**, albeit **dry**, region **that** **has** undergone **major** climatic **changes** **since** 10,000 B.C. **As** recently **as** 6000 B.C., **the** **southern** **frontier** **of** **the** **desert** **was** **far** **to** **the** **north** **of** **where** **it** **is** **now**, **while** semiarid grassland **and** **shallow** freshwater **lakes** **covered** **much** **of** **what** **are** **now** arid **plains**. **This** **was** **a** landscape **where** antelope **of** **all** **kinds** abounded—**along** **with** Bos primigenius, **a** **kind** **of** **oxen** **that** **has** **become** extinct. **The** **areas** **that** **are** **now** **desert** **were**, **like** **all** arid regions, **very** susceptible **to** **cycles** **of** higher **and** lower **levels** **of** **rainfall**, **resulting** **in** **major**, **sudden** **changes** **in** distributions **of** **plants** **and** **animals**. **The** **people** **who** **hunted** **the** sparse **desert** **animals** **responded** **to** drought **by** **managing** **the** **wild** resources **they** **hunted** **and** **gathered**, **especially** **wild** **oxen**, **which** **had** **to** **have** **regular** **water** **supplies** **to** **survive**.

**Even** **before** **the** drought, **the** Sahara **was** **never** **well** **watered**. **Both** **humans** **and** **animals** **were** constantly **on** **the** **move**, **in** **search** **of** **food** **and** **reliable** **water** **supplies**. **Under** **these** **circumstances**, archaeologist Andrew Smith **believes**, **the** **small** herds **of** Bos primigenius **in** **the** **desert** **became** smaller, **more** closely knit breeding **units** **as** **the** drought **took** **hold**. **The** **beasts** **were** **more** disciplined, **so** **that** **it** **was** easier **for** **hunters** **to** **predict** **their** **habits**, **and** capture **animals** **at** **will**. **At** **the** **same** **time**, **both** **cattle** **and** **humans** **were** **more** confined **in** **their** **movements**, **staying** **much** closer **to** **permanent** **water** **supplies** **for** **long** **periods** **of** **time**. **As** **a** **result**, **cattle** **and** **humans** **came** **into** **close** **association**.

Smith **believes** **that** **the** **hunters** **were** **well** **aware** **of** **the** **more** disciplined **ways** **in** **which** **their** prey **behaved**. **Instead** **of** **following** **the** **cattle** **on** **their** **annual** migrations, **the** **hunters** **began** **to** **prevent** **the** herd **from** **moving** **from** **one** **spot** **to** **another**. **At** **first**, **they** **controlled** **the** **movement** **of** **the** herd **while** ensuring continuance **of** **their** **meat** **diet**. **But** **soon** **they** **also** **gained** genetic **control** **of** **the** **animals**, **which** **led** **to** **rapid** **physical** **changes** **in** **the** herd. **South** **African** **farmers** **who** maintain herds **of** **wild** eland (**large** **African** antelopes **with** **short**, **twisted** horns) **report** **that** **the** offspring **soon** diminish **in** **size**, **unless** **wild** bulls **are** **introduced** constantly **from** **outside**. **The** **same** **effects** **of** inbreeding may **have** **occurred** **in** **controlled** **cattle** **populations**, **with** **some** additional, **and** **perhaps** unrecognized, **advantages**. **The** newly domesticated **animals** **behaved** **better**, **were** easier **to** **control**, **and** may **have** **enjoyed** **a** higher **birth** **rate**, **which** **in** **turn** yielded greater **milk** **supplies**. **We** **know** **from** **rock** **paintings** **deep** **in** **the** Sahara **that** **the** herders **were** **soon** **selecting** breeding **animals** **to** **produce** offspring **with** **different** horn **shapes** **and** **hide** colors.

**It** **is** **still** unclear **whether** domesticated **cattle** **were** tamed independently **in** **northern** **Africa** **or** **introduced** **to** **the** **continent** **from** **Southwest** **Asia**. **Whatever** **the** source **of** **the** original tamed herds **might** **have** **been**, **it** **seems** entirely **likely** **that** **much** **the** **same** **process** **of** juxtaposition (**living** **side** **by** **side**) **and** **control** **occurred** **in** **both** **Southwest** **Asia** **and** **northern** **Africa**, **and** **even** **in** **Europe**, **among** **peoples** **who** **had** an intimate **knowledge** **of** **the** behavior **of** **wild** **cattle**. **The** **experiments** **with** domestication **probably** **occurred** **in** **many** **places**, **as** **people** **living** **in** **ever**-**drier** **environments** **cast** **around** **for** **more** predictable **food** **supplies**.

**The** **cattle** herders **had** **only** **a** **few** **possessions**: unsophisticated **pots** **and** **polished** adzes **cutting** **tools** **with** blades **set** **at** **right** **angles** **to** **the** **handle**. **They** **also** **hunted** **with** **bow** **and** **arrow**. **The** Saharan **people** **left** **a** remarkable **record** **of** **their** **lives** **painted** **on** **the** **walls** **of** **caves** **deep** **in** **the** **desert**. **Their** artistic endeavors **have** **been** **preserved** **in** **paintings** **of** **wild** **animals**, **cattle**, **goats**, **humans**, **and** **scenes** **of** **daily** **life** **that** extend **back** **perhaps** **to** 5000 B.C. **The** **widespread** distribution **of** pastoral sites **of** **this** **period** **suggests** **that** **the** Saharans **ranged** **their** herds **over** widely **separated** **summer** **and** **winter** grazing **grounds**.

**About** 3,500B.C., climatic **conditions** **again** deteriorated. **The** Sahara slowly **became** **drier** **and** **lakes** anished. **On** **the** **other** **hand**, **rainfall** **increased** **in** **the** interior **of** **western** **Africa**, **and** **the** **northern** **limit** **of** **the** tsetse **fly**, an **insect** fatal **to** **cattle**, **moved** **south**. **So** **the** herders shifted **south**, **following** **the** **major** **river** **systems** **into** savanna regions. **By** **this** **time**, **the** Saharan **people** **were** **probably** **using** domestic **crops**, **experimenting** **with** **such** **summer** **rainfall** **crops** **as** sorghum **and** millet **as** **they** **moved** **out** **of** **areas** **where** **they** **could** **grow** **wheat**, barley, **and** **other** Mediterranean **crops**.

count: 242

# Official 12-Passage 02 Transition to Sound in Film

**The** shift **from** **silent** **to** **sound** **film** **at** **the** **end** **of** **the** 1920’s **marks**, **so** **far**, **the** **most** **important** transformation **in** motion **picture** **history**. Despite **all** **the** highly visible technological **developments** **in** theatrical **and** **home** delivery **of** **the** **moving** image **that** **have** **occurred** **over** **the** **decades** **since** **then**, **no** **single** innovation **has** **come** **close** **to** **being** **regarded** **as** **a** **similar** **kind** **of** watershed. **In** **nearly** **every** **language**, **however** **the** **words** **are** **phrased**, **the** **most** **basic** **division** **in** **cinema** **history** **lies** **between** **films** **that** **are** mute **and** **films** **that** **speak**.

**Yet** **this** **most** **fundamental** **standard** **of** historical periodization conceals **a** **host** **of** paradoxes. **Nearly** **every** **movie** theater, **however** **modest**, **had** **a** **piano** **or** **organ** **to** **provide** **musical** accompaniment **to** **silent** **pictures**. **In** **many** instances, spectators **in** **the** era **before** **recorded** **sound** **experienced** elaborate aural **presentations** **alongside** **movies**’ **visual** images, **from** **the** **Japanese** benshi (narrators) crafting multivoiced **dialogue** narratives **to** original **musical** **compositions** **performed** **by** **symphony**-**size** orchestras **in** **Europe** **and** **the** **United** **States**. **In** Berlin, **for** **the** premiere **performance** **outside** **the** Soviet **Union** **of** **The** Battleship Potemkin, **film** **director** Sergei Eisenstein worked **with** Austrian composer Edmund Meisel (1874–1930) **on** **a** **musical** **score** **matching** **sound** **to** image; **the** Berlin screenings **with** **live** **music** **helped** **to** **bring** **the** **film** **its** **wide** **international** fame.

**Beyond** **that**, **the** triumph **of** **recorded** **sound** **has** overshadowed **the** **rich** diversity **of** technological **and** aesthetic **experiments** **with** **the** **visual** image **that** **were** **going** **forward** simultaneously **in** **the** 1920’s. **New** color **processes**, larger **or** differently **shaped** **screen** **sizes**, multiple-**screen** projections, **even** **television**, **were** **among** **the** **developments** **invented** **or** **tried** **out** **during** **the** **period**, **sometimes** **with** startling **success**. **The** **high** **costs** **of** converting **to** **sound** **and** **the** **early** limitations **of** **sound** **technology** **were** **among** **the** factors **that** suppressed innovations **or** retarded advancement **in** **these** **other** **areas**. **The** **introduction** **of** **new** **screen** **formats** **was** **put** **off** **for** **a** **quarter** **century**, **and** color, **though** utilized **over** **the** **next** **two** **decades** **for** **special** **productions**, **also** **did** **not** **become** **a** norm **until** **the** 1950’s.

**Though** **it** may **be** **difficult** **to** **imagine** **from** **a** **later** perspective, **a** strain **of** critical **opinion** **in** **the** 1920’s **predicted** **that** **sound** **film** **would** **be** **a** **technical** novelty **that** **would** **soon** **fade** **from** **sight**, **just** **as** **had** **many** previous **attempts**, **dating** **well** **back** **before** **the** **First** **World** **War**, **to** **link** images **with** **recorded** **sound**. **These** critics **were** **making** **a** **common** **assumption**—**that** **the** technological inadequacies **of** earlier **efforts** (**poor** synchronization, **weak** **sound** amplification, **fragile** **sound** recordings) **would** invariably **occur** **again**. **To** **be** **sure**, **their** evaluation **of** **the** **technical** flaws **in** 1920’s **sound** **experiments** **was** **not** **so** **far** **off** **the** **mark**, **yet** **they** neglected **to** **take** **into** **account** **important** **new** **forces** **in** **the** motion **picture** **field** **that**, **in** **a** **sense**, **would** **not** **take** **no** **for** an **answer**.

**These** **forces** **were** **the** rapidly **expanding** **electronics** **and** telecommunications **companies** **that** **were** **developing** **and** **linking** **telephone** **and** wireless **technologies** **in** **the** 1920’s. **In** **the** **United** **States**, **they** **included** **such** **firms** **as** **American** **Telephone** **and** **Telegraph**, **General** **Electric**, **and** Westinghouse. **They** **were** **interested** **in** **all** **forms** **of** **sound** **technology** **and** **all** **potential** **avenues** **for** commercial exploitation. **Their** **competition** **and** collaboration **were** **creating** **the** **broadcasting** **industry** **in** **the** **United** **States**, **beginning** **with** **the** **introduction** **of** commercial **radio** **programming** **in** **the** **early** 1920’s. **With** financial assets considerably greater **than** **those** **in** **the** motion **picture** **industry**, **and** **perhaps** **a** wider vision **of** **the** **relationships** **among** **entertainment** **and** **communications** **media**, **they** revitalized **research** **into** **recording** **sound** **for** motion **pictures**.

**In** 1929 **the** **United** **States** motion **picture** **industry** released **more** **than** 300 **sound** **films**—**a** **rough** **figure**, **since** **a** **number** **were** **silent** **films** **with** **music** **tracks**, **or** **films** **prepared** **in** dual **versions**, **to** **take** **account** **of** **the** **many** **cinemas** **not** **yet** **wired** **for** **sound**. **At** **the** **production** **level**, **in** **the** **United** **States** **the** conversion **was** virtually **complete** **by** 1930. **In** **Europe** **it** **took** **a** **little** longer, mainly **because** **there** **were** **more** **small** producers **for** **whom** **the** **costs** **of** **sound** **were** prohibitive, **and** **in** **other** **parts** **of** **the** **world** **problems** **with** **rights** **or** **access** **to** **equipment** **delayed** **the** shift **to** **sound** **production** **for** **a** **few** **more** **years** (**though** **cinemas** **in** **major** **cities** may **have** **been** **wired** **in** **order** **to** **play** **foreign** **sound** **films**). **The** triumph **of** **sound** **cinema** **was** **swift**, **complete**, **and** enormously **popular**.

count: 242

# Official 33-Passage 01 Railroads and Commercial Agriculture in Nineteenth-Century United States

**By** 1850 **the** **United** **States** **possessed** roughly 9,000 **miles** **of** railroad **track**; **ten** **years** **later** **it** **had** **over** 30,000 **miles**, **more** **than** **the** **rest** **of** **the** **world** **combined**. **Much** **of** **the** **new** **construction** **during** **the** 1850s **occurred** **west** **of** **the** Appalachian **Mountains**—**over** 2,000 **miles** **in** **the** **states** **of** Ohio **and** Illinois **alone**.

**The** **effect** **of** **the** **new** railroad **lines** rippled **outward** **through** **the** economy. **Farmers** **along** **the** **tracks** **began** **to** specialize **in** **crops** **that** **they** **could** **market** **in** **distant** locations. **With** **their** **profits** **they** **purchased** manufactured **goods** **that** earlier **they** **might** **have** **made** **at** **home**. **Before** **the** railroad **reached** Tennessee, **the** **state** **produced** **about** 25,000 bushels (**or** 640 **tons**) **of** **wheat**, **which** **sold** **for** **less** **than** 50 **cents** **a** bushel. **Once** **the** railroad **came**, **farmers** **in** **the** **same** counties **grew** 400,000 bushels (**over** 10,000 **tons**) **and** **sold** **their** **crop** **at** **a** **dollar** **a** bushel.

**The** **new** railroad **networks** shifted **the** **direction** **of** **western** **trade**. **In** 1840 **most** northwestern **grain** **was** **shipped** **south** **down** **the** Mississippi **River** **to** **the** bustling **port** **of** **New** Orleans. **But** **low** **water** **made** steamboat **travel** hazardous **in** **summer**, **and** **ice** **shut** **down** **traffic** **in** **winter**. **Products** **such** **as** lard, tallow, **and** **cheese** quickly spoiled **if** **stored** **in** **New** Orleans’ **hot** **and** humid **warehouses**. Increasingly, **traffic** **from** **the** Midwest **flowed** **west** **to** **east**, **over** **the** **new** **rail** **lines**. Chicago **became** **the** region’s hub, **linking** **the** **farms** **of** **the** **upper** Midwest **to** **New York** York **and** **other** **eastern** **cities** **by** **more** **than** 2,000 **miles** **of** **track** **in** 1855. **Thus** **while** **the** **value** **of** **goods** **shipped** **by** **river** **to** **New** Orleans **continued** **to** **increase**, **the** **South**’s overall **share** **of** **western** **trade** **dropped** dramatically.

**A** **sharp** **rise** **in** **demand** **for** **grain** **abroad** **also** **encouraged** **farmers** **in** **the** **Northeast** **and** Midwest **to** **become** **more** commercially oriented. **Wheat**, **which** **in** 1845 **commanded** $1.08 **a** bushel **in** **New York** York **City**, **fetched** $2.46 **in** 1855; **in** **similar** fashion **the** **price** **of** **corn** **nearly** **doubled**. **Farmers** **responded** **by** specializing **in** **cash** **crops**, **borrowing** **to** **purchase** **more** **land**, **and** investing **in** **equipment** **to** **increase** productivity.

**As** railroad **lines** **fanned** **out** **from** Chicago, **farmers** **began** **to** **acquire** **open** **prairie** **land** **in** Illinois **and** **then** Iowa, **putting** **the** fertile, **deep** **black** **soil** **into** **production**. Commercial **agriculture** **transformed** **this** remarkable treeless **environment**. **To** **settlers** **accustomed** **to** **eastern** woodlands, **the** **thousands** **of** **square** **miles** **of** **tall** **grass** **were** an **awesome** **sight**. **Indian** **grass**, **Canada** **wild** rye, **and** **native** **big** bluestem **all** **grew** higher **than** **a** **person**. **Because** **eastern** plows **could** **not** penetrate **the** densely tangled **roots** **of** **prairie** **grass**, **the** earliest **settlers** erected **farms** **along** **the** **boundary** **separating** **the** **forest** **from** **the** **prairie**. **In** 1837, **however**, John Deere **patented** **a** **sharp**-**cutting** **steel** plow **that** **sliced** **through** **the** sod **without** **soil** **sticking** **to** **the** blade. Cyrus McCormick refined **a** mechanical reaper **that** **harvested** **fourteen** **times** **more** **wheat** **with** **the** **same** **amount** **of** labor. **By** **the** 1850s McCormick **was** **selling** 1,000 reapers **a** **year** **and** **could** **not** **keep** **up** **with** **demand**, **while** Deere **turned** **out** 10,000 plows annually.

**The** **new** commercial **farming** fundamentally altered **the** midwestern landscape **and** **the** **environment**. **Native** Americans **had** **grown** **corn** **in** **the** region **for** **years**, **but** **never** **in** **such** **large** **fields** **as** **did** **later** **settlers** **who** **became** **farmers**, **whose** **surpluses** **were** **shipped** **east**. **Prairie** **farmers** **also** **introduced** **new** **crops** **that** **were** **not** **part** **of** **the** earlier ecological **system**, notably **wheat**, **along** **with** **fruits** **and** **vegetables**.

**Native** **grasses** **were** **replaced** **by** **a** **small** **number** **of** **plants** cultivated **as** commodities. **Corn** **had** **the** **best** yields, **but** **it** **was** primarily **used** **to** **feed** livestock. **Because** **bread** **played** **a** **key** **role** **in** **the** **American** **and** **European** **diet**, **wheat** **became** **the** **major** **cash** **crop**. Tame **grasses** **replaced** **native** **grasses** **in** pastures **for** **making** **hay**.

**Western** **farmers** altered **the** landscape **by** **reducing** **the** **annual** **fires** **that** **had** **kept** **the** **prairie** **free** **from** **trees**. **In** **the** **absence** **of** **these** **fires**, **trees** reappeared **on** **land** **not** **in** cultivation **and**, **if** undisturbed, **eventually** **formed** woodlots. **The** earlier unbroken landscape **gave** **way** **to** **independent** **farms**, **each** **fenced** **off** **in** **a** **precise** checkerboard **pattern**. **It** **was** an **artificial** ecosystem **of** **animals**, woodlots, **and** **crops**, **whose** **large**, **uniform** layout **made** **western** **farms** **more** efficient **than** **the** **more**-irregular **farms** **in** **the** **East**.

count: 241

# Official 30-Passage 01 Role of Play in Development

**Play** **is** easier **to** define **with** **examples** **than** **with** **concepts**. **In** **any** **case**, **in** **animals** **it** **consists** **of** leaping, **running**, **climbing**, **throwing**, **wrestling**, **and** **other** **movements**, **either** **alone**, **with** **objects**, **or** **with** **other** **animals**. **Depending** **on** **the** species, **play** may **be** primarily **for** **social** interaction, **exercise**, **or** exploration. **One** **of** **the** **problems** **in** **providing** **a** **clear** definition **of** **play** **is** **that** **it** involves **the** **same** behaviors **that** **take** **place** **in** **other** **circumstances** – dominance, predation, **competition**, **and** **real** **fighting**. **Thus**, **whether** **play** **occurs** **or** **not** **depends** **on** **the** **intention** **of** **the** **animal**, **and** **intentions** **are** **not** **always** **clear** **from** behavior **alone**.

**Play** **appears** **to** **be** **a** developmental **characteristic** **of** **animals** **with** **fairly** sophisticated **nervous** **systems**, mainly **birds** **and** mammals. **Play** **has** **been** **studied** **most** extensively **in** primates **and** canids (**dogs**). **Exactly** **why** **animals** **play** **is** **still** **a** **matter** **debated** **in** **the** **research** **literature**, **and** **the** **reasons** may **not** **be** **the** **same** **for** **every** species **that** **plays**. **Determining** **the** **functions** **of** **play** **is** **difficult** **because** **the** **functions** may **be** **long**-**term**, **with** **beneficial** **effects** **not** **showing** **up** **until** **the** **animal**’s adulthood.

**Play** **is** **not** **without** considerable **costs** **to** **the** individual **animal**. **Play** **is** **usually** **very** **active**, involving **movement** **in** **space** **and**, **at** **times**, noisemaking. **Therefore**, **it** **results** **in** **the** **loss** **of** **fuel** **or** energy **that** **might** **better** **be** **used** **for** **growth** **or** **for** **building** **up** **fat** **stores** **in** **a** **young** **animal**. **Another** **potential** **cost** **of** **this** **activity** **is** greater exposure **to** predators **since** **play** **is** **attention**-**getting** behavior. Greater **activity** **also** **increases** **the** **risk** **of** **injury** **in** **slipping** **or** **falling**.

**The** **benefits** **of** **play** must outweigh **the** **costs**, **or** **play** **would** **not** **have** evolved, **according to** Darwin’s **theory**. **Some** **of** **the** **potential** **benefits** **relate** directly **to** **the** **healthy** **development** **of** **the** **brain** **and** **nervous** **system**. **In** **one** **research** **study**, **two** **groups** **of** **young** **rats** **were** **raised** **under** **different** **conditions**. **One** **group** **developed** **in** an “enriched” **environment**, **which** **allowed** **the** **rats** **to** interact **with** **other** **rats**, **play** **with** **toys**, **and** **receive** maze **training**. **The** **other** **group** **lived** **in** an “impoverished” **environment** **in** individual **cages** **in** **a** dimly **lit** **room** **with** **little** stimulation. **At** **the** **end** **of** **the** **experiments**, **the** **results** **showed** **that** **the** **actual** **weight** **of** **the** **brains** **of** **the** impoverished **rats** **was** **less** **than** **that** **of** **those** **raised** **in** **the** enriched **environment** (**though** **they** **were** **fed** **the** **same** **diets**). **Other** **studies** **have** **shown** **that** greater stimulation **not** **only** **affects** **the** **size** **of** **the** **brain** **but** **also** **increases** **the** **number** **of** **connections** **between** **the** nerve **cells**. **Thus**, **active** **play** may **provide** **necessary** stimulation **to** **the** **growth** **of** synaptic **connections** **in** **the** **brain**, **especially** **the** cerebellum, **which** **is** responsible **for** **motor** **functioning** **and** **movements**.

**Play** **also** stimulates **the** **development** **of** **the** muscle **tissues** **themselves** **and** may **provide** **the** opportunity **to** **practice** **those** **movements** **needed** **for** **survival**. Prey species, **like** **young** **deer** **or** **goats**, **for** **example**, typically **play** **by** **performing** **sudden** **flight** **movements** **and** **turns**, whereas predator species, **such** **as** **cats**, **practice** stalking, pouncing, **and** **biting**.

**Play** **allows** **a** **young** **animal** **to** **explore** **its** **environment** **and** **practice** **skills** **in** comparative **safety** **since** **the** **surrounding** **adults** generally **do** **not** **expect** **the** **young** **to** **deal** **with** threats **or** predators. **Play** **can** **also** **provide** **practice** **in** **social** behaviors **needed** **for** courtship **and** **mating**. **Learning** **appropriate** **social** behaviors **is** **especially** **important** **in** species **that** **live** **in** **groups**, **like** **young** **monkeys** **that** **need** **to** **learn** **to** **control** selfishness **and** **aggression** **and** **to** **understand** **the** **give**-**and**-**take** involved **in** **social** **groups**. **They** **need** **to** **learn** **how** **to** **be** dominant **and** submissive **because** **each** **monkey** **might** **have** **to** **play** **either** **role** **in** **the** **future**. **Most** **of** **these** **things** **are** **learned** **in** **the** **long** developmental **periods** **that** primates **have**, **during** **which** **they** engage **in** countless **play** **experiences** **with** **their** peers.

**There** **is** **a** **danger**, **of** **course**, **that** **play** may **be** misinterpreted **or** **not** recognized **as** **play** **by** **others**, potentially **leading** **to** **aggression**. **This** **is** **especially** **true** **when** **play** **consists** **of** **practicing** **normal** **aggressive** **or** predatory behaviors. **Thus**, **many** species **have** evolved **clear** **signals** **to** delineate playfulness. **Dogs**, **for** **example**, **will** **wag** **their** **tails**, **get** **down** **on** **their** **front** **legs**, **and** **stick** **their** **behinds** **in** **the** **air** **to** indicate “**what** **follows** **is** **just** **for** **play**.”

count: 240

# Official 30-Passage 03 The Invention of the Mechanical Clock

**In** **Europe**, **before** **the** **introduction** **of** **the** mechanical **clock**, **people** **told** **time** **by** **sun** (**using**, **for** **example**, **shadow** **sticks** **or** **sun** **dials**) **and** **water** **clocks**. **Sun** **clocks** worked, **of** **course**, **only** **on** **clear** **days**; **water** **clocks** misbehaved **when** **the** **temperature** **fell** **toward** **freezing**, **to** **say** **nothing** **of** **long**-**run** drift **as** **the** **result** **of** sedimentation **and** clogging. **Both** **these** devices worked **well** **in** **sunny** **climates**; **but** **in** **northern** **Europe** **the** **sun** may **be** hidden **by** **clouds** **for** **weeks** **at** **a** **time**, **while** **temperatures** vary **not** **only** seasonally **but** **from** **day** **to** **night**.

Medieval **Europe** **gave** **new** **importance** **to** **reliable** **time**. **The** **Catholic** **Church** **had** **its** **seven** **daily** **prayers**, **one** **of** **which** **was** **at** **night**, **requiring** an **alarm** **arrangement** **to** waken monks **before** **dawn**. **And** **then** **the** **new** **cities** **and** **towns**, **squeezed** **by** **their** **walls**, **had** **to** **know** **and** **order** **time** **in** **order** **to** organize collective **activity** **and** ration **space**. **They** **set** **a** **time** **to** **go** **to** **work**, **to** **open** **the** **market**, **to** **close** **the** **market**, **to** **leave** **work**, **and** finally **a** **time** **to** **put** **out** **fires** **and** **go** **to** **sleep**. **All** **this** **was** compatible **with** older devices **so** **long** **as** **there** **was** **only** **one** authoritative timekeeper; **but** **with** **urban** **growth** **and** **the** multiplication **of** **time** **signals**, discrepancy **brought** discord **and** strife. **Society** **needed** **a** **more** dependable **instrument** **of** **time** measurement **and** **found** **it** **in** **the** mechanical **clock**.

**We** **do** **not** **know** **who** **invented** **this** **machine**, **or** **where**. **It** **seems** **to** **have** **appeared** **in** **Italy** **and** **England** (**perhaps** simultaneous **invention**) **between** 1275 **and** 1300. **Once** **known**, **it** **spread** rapidly, **driving** **out** **water** **clocks** **but** **not** **solar** **dials**, **which** **were** **needed** **to** **check** **the** **new** **machines** **against** **the** timekeeper **of** **last** resort. **These** **early** **versions** **were** rudimentary, inaccurate, **and** prone **to** breakdown.

Ironically, **the** **new** **machine** **tended** **to** undermine **Catholic** **Church** **authority**. **Although** **church** ritual **had** sustained an **interest** **in** timekeeping **throughout** **the** **centuries** **of** **urban** collapse **that** **followed** **the** **fall** **of** Rome, **church** **time** **was** **nature**’s **time**. **Day** **and** **night** **were** **divided** **into** **the** **same** **number** **of** **parts**, **so** **that** **except** **at** **the** equinoxes, **day** **and** **night** **hours** **were** unequal; **and** **then** **of** **course** **the** **length** **of** **these** **hours** varied **with** **the** **seasons**. **But** **the** mechanical **clock** **kept** **equal** **hours**, **and** **this** implied **a** **new** **time** reckoning. **The** **Catholic** **Church** **resisted**, **not** **coming** **over** **to** **the** **new** **hours** **for** **about** **a** **century**. **From** **the** **start**, **however**, **the** **towns** **and** **cities** **took** **equal** **hours** **as** **their** **standard**, **and** **the** **public** **clocks** installed **in** **town** **halls** **and** **market** **squares** **became** **the** **very** **symbol** **of** **a** **new**, secular municipal **authority**. **Every** **town** **wanted** **one**; conquerors **seized** **them** **as** **especially** **precious** spoils **of** **war**; **tourists** **came** **to** **see** **and** **hear** **these** **machines** **the** **way** **they** **made** pilgrimages **to** **sacred** relics.

**The** **clock** **was** **the** greatest **achievement** **of** medieval mechanical ingenuity. **Its** **general** **accuracy** **could** **be** **checked** **against** **easily** **observed** **phenomena**, **like** **the** **rising** **and** **setting** **of** **the** **sun**. **The** **result** **was** relentless **pressure** **to** **improve** **technique** **and** **design**. **At** **every** **stage**, clockmakers **led** **the** **way** **to** **accuracy** **and** precision; **they** **became** **masters** **of** miniaturization, detectors **and** correctors **of** **error**, searchers **for** **new** **and** **better**. **They** **were** **thus** **the** **pioneers** **of** mechanical **engineering** **and** **served** **as** **examples** **and** **teachers** **to** **other** **branches** **of** **engineering**.

**The** **clock** **brought** **order** **and** **control**, **both** collective **and** **personal**. **Its** **public** display **and** **private** **possession** **laid** **the** **basis** **for** temporal autonomy: **people** **could** **now** coordinate comings **and** goings **without** **dictation** **from** **above**. **The** **clock** **provided** **the** **punctuation** **marks** **for** **group** **activity**, **while** enabling individuals **to** **order** **their** **own** **work** (**and** **that** **of** **others**) **so** **as** **to** enhance productivity. **Indeed**, **the** **very** notion **of** productivity **is** **a** **by**-**product** **of** **the** **clock**: **once** **one** **can** **relate** **performance** **to** **uniform** **time** **units**, **work** **is** **never** **the** **same**. **One** **moves** **from** **the** **task**-oriented **time** consciousness **of** **the** **peasant** (**working** **one** **job** after **another**, **as** **time** **and** **light** **permit**) **and** **the** **time**-**filling** busyness **of** **the** domestic **servant** (**who** **always** **had** **something** **to** **do**) **to** an **effort** **to** maximize **product** **per** **unit** **of** **time**.

count: 239

# Official 49-Passage 03 Background for the Industrial Revolution

**The** Industrial **Revolution** **had** **several** **roots**, **one** **of** **which** **was** **a** commercial **revolution** **that**, **beginning** **as** **far** **back** **as** **the** **sixteenth** **century**, **accompanied** **Europe**’s expansion overseas. **Both** **exports** **and** **imports** **showed** spectacular **growth**, particularly **in** **England** **and** **France**. An increasingly larger portion **of** **the** **stepped**-**up** commercial **activity** **was** **the** **result** **of** **trade** **with** overseas colonies. **Imports** **included** **a** **variety** **of** **new** beverages, spices, **and** foodstuffs. **At** **the** **same** **time**, **a** **growing** **export** **market** **took** **European** textiles, hardware, firearms, **ships**, **and** **ships**’ **goods** **around** **the** **world** **and** **brought** **money** **flowing** **back**. **Europe**’s economic **institutions**, particularly **those** **in** **England**, **were** **strong**, **had** **wealth** **available** **for** **new** investment, **and** **seemed** **almost** **to** **be** **waiting** **for** **some** technological **breakthrough** **that** **would** **expand** **their** **profit**-**making** **potential** **even** **more**.

**That** **breakthrough** **came** **in** **Great** **Britain**, **where** **several** economic **advantages** **created** **a** **climate** **especially** favorable **to** **the** **encouragement** **of** **new** **technology**. **One** **was** **its** geographic location **at** **the** **crossroads** **of** **international** **trade**. Internally, **Britain** **was** endowed **with** **easily** navigable **natural** waterways, **which** **helped** **its** **trade** **and** **communication** **with** **the** **world**. **Beginning** **in** **the** 1770’s, **it** **enjoyed** **a** **boom** **in** **canal** **building**, **which** **helped** **make** **its** domestic **markets** **more** **accessible**. **Because** **water** transportation **was** **the** cheapest **means** **of** **carrying** **goods** **to** **market**, **canals** **reduced** **prices** **and** **thus** **increased** consumer **demand**. **Great** **Britain** **also** **had** **rich** **deposits** **of** **coal** **that** **fed** **the** **factories** **springing** **up** **in** industrial **areas** **and** **iron** ore **that** **provided** **the** **raw material** **for** **the** manufacture **of** railroad **equipment**, **tools**, **and** **a** **variety** **of** industrial **and** consumer **goods**.

**Another** **advantage** **was** **Britain**’s **large** **population** **of** rural, **agricultural** **wage** earners, **as** **well** **as** **cottage** **workers**

**Great** **Britain**’s **better**-**developed** **banking** **and** **credit** **system** **also** **helped** **speed** **the** industrial **process**, **as** **did** **the** **fact** **that** **it** **was** **the** **home** **of** an impressive array **of** entrepreneurs **and** **inventors**. **Among** **them** **were** **a** **large** **number** **of** nonconformists **whose** **religious** **principles** **encouraged** thrift **and** **industry** **rather** **than** luxurious **living** **and** **who** **tended** **to** **pour** **their** **profits** **back** **into** **their** **businesses**, **thus** **providing** **the** **basis** **for** **continued** expansion.

**A** precursor **to** **the** Industrial **Revolution** **was** **a** **revolution** **in** **agricultural** **techniques**. **Ideas** **about** **agricultural** **reform** **developed** **first** **in** Holland, **where** **as** **early** **as** **the** mid-seventeenth **century**, **such** **modern** **methods** **as** **crop** rotation, **heavy** fertilization, **and** diversification **were** **all** **in** **use**. Dutch **peasant** **farmers** **were** **known** **throughout** **Europe** **for** **their** **agricultural** innovations, **but** **as** **British** **markets** **and** opportunities **grew**, **the** **English** quickly **learned** **from** **them**. **As** **early** **as** **the** seventeenth **century** **the** Dutch **were** **helping** **them** drain marshes **and** fens **where**, **with** **the** **help** **of** **advanced** **techniques**, **they** **grew** **new** **crops**. **By** **the** mid-eighteenth **century** **new** **agricultural** **methods** **as** **well** **as** selective breeding **of** livestock **had** **caught** **on** **throughout** **the** **country**.

**Much** **of** **the** **increased** **production** **was** **consumed** **by** **Great** **Britain**’s burgeoning **population**. **At** **the** **same** **time**, **people** **were** **moving** **to** **the** **city**, **partly** **because** **of** **the** enclosure **movement**; **that** **is**, **the** **fencing** **of** **common** **fields** **and** pastures **in** **order** **to** **provide** **more** compact, efficient privately **held** **agricultural** **parcels** **that** **would** **produce** **more** **goods** **and** greater **profits**. **In** **the** **sixteenth** **century** enclosures **were** **usually** **used** **for** **creating** **sheep** pastures, **but** **by** **the** eighteenth **century** **new** **farming** **techniques** **made** **it** advantageous **for** **large** landowners **to** **seek** enclosures **in** **order** **to** **improve** **agricultural** **production**. **Between** 1714 **and** 1820 **over** 6 **million** **acres** **of** **English** **land** **were** enclosed. **As** **a** **result**, **many** **small**, **independent** **farmers** **were** **forced** **to** **sell** **out** **simply** **because** **they** **could** **not** **compete**. Nonlandholding **peasants** **and** **cottage** **workers**, **who** worked **for** **wages** **and** grazed **cows** **or** **pigs** **on** **the** **village** **common**, **were** **also** **hurt** **when** **the** **common** **was** **no** longer **available**. **It** **was** **such** **people** **who** **began** **to** flock **to** **the** **cities** **seeking** employment **and** **who** **found** **work** **in** **the** **factories** **that** **would** **transform** **the** **nation** **and**, **the** **world**.

count: 238

# Official 24-Passage 03 Moving into Pueblos

**In** **the** Mesa Verde **area** **of** **the** **ancient** **North** **American** **Southwest**, **living** **patterns** **changed** **in** **the** thirteenth **century**, **with** **large** **numbers** **of** **people** **moving** **into** **large** communal dwellings **called** pueblos, **often** **constructed** **at** **the** **edges** **of** canyons, **especially** **on** **the** **sides** **of** cliffs. **Abandoning** **small** extended-**family** households **to** **move** **into** **these** **large** pueblos **with** **dozens** **if** **not** **hundreds** **of** **other** **people** **was** **probably** traumatic. **Few** **of** **the** cultural **traditions** **and** **rules** **that** **today** **allow** us **to** **deal** **with** dense **populations** **existed** **for** **these** **people** **accustomed** **to** household autonomy **and** **the** **ability** **to** **move** **around** **the** landscape **almost** **at** **will**. **And** **besides** **the** awkwardness **of** **having** **to** **share** **walls** **with** neighbors, **living** **in** aggregated pueblos **introduced** **other** **problems**. **For** **people** **in** cliff dwellings, hauling **water**, **wood**, **and** **food** **to** **their** **homes** **was** **a** **major** chore. **The** **stress** **on** **local** resources, **especially** **in** **the** **firewood** **needed** **for** **daily** **cooking** **and** **warmth**, **was** particularly intense, **and** **conditions** **in** aggregated pueblos **were** **not** **very** hygienic.

**Given** **all** **the** **disadvantages** **of** **living** **in** aggregated **towns**, **why** **did** **people** **in** **the** thirteenth **century** **move** **into** **these** closely **packed** **quarters**? **For** transitions **of** **such** suddenness, archaeologists **consider** **either** **pull** factors (**benefits** **that** **drew** **families** **together**) **or** **push** factors (**some** external threat **or** crisis **that** **forced** **people** **to** aggregate). **In** **this** **case**, **push** **explanations** dominate.

**Population** **growth** **is** **considered** **a** particularly influential **push**. After **several** **generations** **of** **population** **growth**, **people** **packed** **the** landscape **in** densities **so** **high** **that** communal pueblos may **have** **been** **a** **necessary** **outcome**. **Around** **Sand** Canyon, **for** **example**, **populations** **grew** **from** 5–12 **people** **per** **square** kilometer **in** **the** tenth **century** **to** **as** **many** **as** 30–50 **by** **the** 1200s. **As** densities **increased**, domestic **architecture** **became** larger, culminating **in** **crowded** pueblos. **Some** **scholars** **expand** **on** **this** **idea** **by** emphasizing **a** **corresponding** **need** **for** arable **land** **to** **feed** **growing** **numbers** **of** **people**: **construction** **of** **small** **dams**, reservoirs, terraces, **and** **field** **houses** indicates **that** **farmers** **were** intensifying **their** **efforts** **during** **the** 1200s. **Competition** **for** **good** farmland may **also** **have** prompted **people** **to** **bond** **together** **to** assert **rights** **over** **the** **best** **fields**.

**Another** **important** **push** **was** **the** onset **of** **the** **Little** **Ice** **Age**, **a** climatic **phenomenon** **that** **led** **to** cooler **temperatures** **in** **the** **Northern** Hemisphere. **Although** **the** **height** **of** **the** **Little** **Ice** **Age** **was** **still** **around** **the** **corner**, **some** **evidence** **suggests** **that** **temperatures** **were** **falling** **during** **the** thirteenth **century**. **The** environmental **changes** **associated** **with** **this** transition **are** **not** fully **understood**, **but** **people** **living** closest **to** **the** San Juan **Mountains**, **to** **the** **northeast** **of** Mesa Verde, **were** **affected** **first**. **Growing** **food** **at** **these** elevations **is** **always** **difficult** **because** **of** **the** **short** **growing** **season**. **As** **the** **Little** **Ice** **Age** **progressed**, **farmers** **probably** **moved** **their** **fields** **to** lower elevations, infringing **on** **the** **lands** **of** **other** **farmers** **and** **pushing** **people** **together**, **thus** **contributing** **to** **the** aggregations. Archaeologists identify **a** **corresponding** shift **in** **populations** **toward** **the** **south** **and** **west** **toward** Mesa Verde **and** **away** **from** higher elevations.

**In** **the** **face** **of** **all** **these** **pushes**, **people** **in** **the** Mesa Verde **area** **had** **yet** **another** **reason** **to** **move** **into** communal **villages**: **the** **need** **for** greater cooperation. **Sharing** **and** cooperation **were** **almost** **certainly** **part** **of** **early** Puebloan **life**, **even** **for** **people** **living** **in** largely **independent** **single**-household residences scattered **across** **the** landscape. Archaeologists **find** **that** **even** **the** **most** isolated residences **during** **the** eleventh **and** **twelfth** **centuries** **obtained** **some** pottery, **and** **probably** **food**, **from** **some** **distance** **away**, **while** **major** ceremonial **events** **were** opportunities **for** **sharing** **food** **and** crafts. **Scholars** **believe** **that** **this** cooperation **allowed** **people** **to** contend **with** **a** patchy **environment** **in** **which** precipitation **and** **other** resources varied **across** **the** landscape: **if** **you** **produce** **a** **lot** **of** **food** **one** **year**, **you** **might** **trade** **it** **for** pottery **made** **by** **a** **distant** ally **who** **is** **having** **difficulty** **with** **crops**—**and** **the** **next** **year**, **the** **flow** **of** **goods** **might** **go** **in** **the** **opposite** **direction**. **But** **all** **of** **this** **appears** **to** **have** **changed** **in** **the** thirteenth **century**. **Although** **the** **climate** **remained** **as** unpredictable **as** **ever** **between** **one** **year** **and** **the** **next**, **it** **became** **much** **less** locally **diverse**. **In** **a** **bad** **year** **for** **farming**, **everyone** **was** equally **affected**. **No** longer **was** **it** **helpful** **to** **share** widely. **Instead**, **the** **most** sensible **thing** **would** **be** **for** neighbors **to** **combine** **efforts** **to** **produce** **as** **much** **food** **as** **possible**, **and** **thus** aggregated **towns** **were** **a** sensible **arrangement**.

count: 238

# Official 04-Passage 01 Deer Populations of the Puget Sound

**Two** species **of** **deer** **have** **been** prevalent **in** **the** Puget **Sound** **area** **of** Washington **state** **in** **the** **Pacific** **Northwest** **of** **the** **United** **States**. **The** **black**-**tailed** **deer**, **a** lowland, **west**-**side** **cousin** **of** **the** mule **deer** **of** **eastern** Washington, **is** **now** **the** **most** **common**. **The** **other** species, **the** Columbian **white**-**tailed** **deer**, **in** earlier **times** **was** **common** **in** **the** **open** **prairie** **country**; **it** **is** **now** **restricted** **to** **the** **low**, marshy **islands** **and** **flood** **plains** **along** **the** lower Columbia **River**.

**Nearly** **any** **kind** **of** **plant** **of** **the** **forest** understory **can** **be** **part** **of** **a** **deer**’s **diet**. **Where** **the** **forest** inhibits **the** **growth** **of** **grass** **and** **other** meadow **plants**, **the** **black**-**tailed** **deer** browses **on** huckleberry, salal, dogwood, **and** **almost** **any** **other** shrub **or** **herb**. **But** **this** **is** **fair**-**weather** **feeding**. **What** **keeps** **the** **black**-**tailed** **deer** **alive** **in** **the** harsher **seasons** **of** **plant** decay **and** dormancy? **One** compensation **for** **not** **hibernating** **is** **the** **built**-**in** **urge** **to** migrate. **Deer** may **move** **from** **high**-elevation browse **areas** **in** **summer** **down** **to** **the** lowland **areas** **in** **late** **fall**. **Even** **with** **snow** **on** **the** **ground**, **the** **high** bushy understory **is** **exposed**; **also** **snow** **and** **wind** **bring** **down** leafy **branches** **of** cedar, hemlock, **red** alder, **and** **other** arboreal fodder.

**The** **numbers** **of** **deer** **have** fluctuated markedly **since** **the** **entry** **of** Europeans **into** Puget **Sound** **country**. **The** **early** **explorers** **and** **settlers** **told** **of** **abundant** **deer** **in** **the** **early** 1800s **and** **yet** **almost** **in** **the** **same** **breath** bemoaned **the** **lack** **of** **this** succulent **game** **animal**. **Famous** **explorers** **of** **the** **North** **American** **frontier**, Lewis **and** Clark **arrived** **at** **the** **mouth** **of** **the** Columbia **River** **on** **November** 14, 1805, **in** **nearly** **starved** **circumstances**. **They** **had** **experienced** **great** **difficulty** **finding** **game** **west** **of** **the** Rockies **and** **not** **until** **the** **second** **of** **December** **did** **they** **kill** **their** **first** elk. **To** **keep** 40 **people** **alive** **that** **winter**, **they** **consumed** **approximately** 150 elk **and** 20 **deer**. **And** **when** **game** **moved** **out** **of** **the** lowlands **in** **early** **spring**, **the** expedition **decided** **to** **return** **east** **rather** **than** **face** **possible** **starvation**. **Later** **on** **in** **the** **early** **years** **of** **the** nineteenth **century**, **when** Fort Vancouver **became** **the** headquarters **for** **the** Hudson’s **Bay** **Company**, **deer** **populations** **continued** **to** fluctuate. David Douglas, **Scottish** **botanical** **explorer** **of** **the** 1830s, **found** **a** **disturbing** **change** **in** **the** **animal** **life** **around** **the** fort **during** **the** **period** **between** **his** **first** **visit** **in** 1825 **and** **his** **final** contact **with** **the** fort **in** 1832. **A** **recent** Douglas biographer **states**: “**The** **deer** **which** **once** picturesquely **dotted** **the** meadows **around** **the** fort **were** **gone** [**in** 1832], **hunted** **to** extermination **in** **order** **to** **protect** **the** **crops**.”

Reduction **in** **numbers** **of** **game** **should** **have** boded **ill** **for** **their** **survival** **in** **later** **times**. **A** worsening **of** **the** plight **of** **deer** **was** **to** **be** **expected** **as** **settlers** encroached **on** **the** **land**, logging, **burning**, **and** **clearing**, **eventually** **replacing** **a** wilderness landscape **with** **roads**, **cities**, **towns**, **and** **factories**. **No** **doubt** **the** **numbers** **of** **deer** **declined** **still** further. Recall **the** fate **of** **the** Columbian **white**-**tailed** **deer**, **now** **in** **a** **protected** **status**. **But** **for** **the** **black**-**tailed** **deer**, **human** **pressure** **has** **had** **just** **the** **opposite** **effect**. **Wildlife** zoologist Helmut Buechner (1953), **in** **reviewing** **the** **nature** **of** biotic **changes** **in** Washington **through** **recorded** **time**, **says** **that** “**since** **the** **early** 1940s, **the** **state** **has** **had** **more** **deer** **than** **at** **any** **other** **time** **in** **its** **history**, **the** **winter** **population** fluctuating **around** **approximately** 320,000 **deer** (mule **and** **black**-**tailed** **deer**), **which** **will** yield **about** 65,000 **of** **either** **sex** **and** **any** **age** annually **for** an indefinite **period**.”

**The** **causes** **of** **this** **population** rebound **are** **consequences** **of** **other** **human** **actions**. **First**, **the** **major** predators **of** **deer**—**wolves**, cougar, **and** lynx—**have** **been** greatly **reduced** **in** **numbers**. **Second**, **conservation** **has** **been** **insured** **by** **limiting** **times** **for** **and** **types** **of** **hunting**. **But** **the** **most** profound **reason** **for** **the** restoration **of** **high** **population** **numbers** **has** **been** **the** fate **of** **the** **forests**. **Great** tracts **of** lowland **country** deforested **by** logging, **fire**, **or** **both** **have** **become** ideal **feeding** **grounds** **for** **deer**. **In** **addition** **to** **finding** an **increase** **of** **suitable** browse, **like** huckleberry **and** vine **maple**, Arthur Einarsen, longtime **game** biologist **in** **the** **Pacific** **Northwest**, **found** **quality** **of** browse **in** **the** **open** **areas** **to** **be** substantially **more** nutritive. **The** protein **content** **of** **shade**-**grown** vegetation, **for** **example**, **was** **much** lower **than** **that** **for** **plants** **grown** **in** clearings.

count: 237

# Official 52-Passage 03 Early Food Production in Sub-Saharan Africa

**At** **the** **end** **of** **the** Pleistocene (**around** 10,000 B.C.), **the** **technologies** **of** **food** **production** may **have** **already** **been** **employed** **on** **the** fringes **of** **the** **rain** **forests** **of** **western** **and** **central** **Africa**, **where** **the** **common** **use** **of** **such** **root** **plants** **as** **the** **African** yam **led** **people** **to** recognize **the** **advantages** **of** **growing** **their** **own** **food**. **The** yam **can** **easily** **be** resprouted **if** **the** **top** **is** replanted. **This** **primitive** **form** **of** “vegeculture” (cultivation **of** **root** **and** **tree** **crops**) may **have** **been** **the** economic **tradition** **onto** **which** **the** cultivation **of** **summer** **rainfall** cereal **crops** **was** grafted **as** **it** **came** **into** **use** **south** **of** **the** grassland **areas** **on** **the** Sahara’s **southern** **borders**.

**As** **the** Sahara **dried** **up** after 5000 B.C., pastoral **peoples** (**cattle** herders) **moved** southward **along** **major** watercourses **into** **the** savanna **belt** **of** **West** **Africa** **and** **the** Sudan. **By** 3000 B.C., **just** **as** **ancient** **Egyptian** **civilization** **was** **coming** **into** **being** **along** **the** Nile, **they** **had** **settled** **in** **the** **heart** **of** **the** **East** **African** highlands **far** **to** **the** **south**. **The** **East** **African** highlands **are** ideal **cattle** **country** **and** **the** **home** **today** **of** **such** **famous** **cattle**-herding **peoples** **as** **the** Masai. **The** highlands **were** inhabited **by** **hunter**-gatherers **living** **around** **mountains** **near** **the** **plains** **until** **about** 3300 B.C., **when** **the** **first** **cattle** herders **appeared**. **These** **cattle** **people** may **have** **moved** **between** **fixed** **settlements** **during** **the** **wet** **and** **dry** **seasons**, **living** **off** **hunting** **in** **the** **dry** **months** **and** **their** **own** livestock **and** **agriculture** **during** **the** **rains**.

**As** **was** **the** **case** elsewhere, **cattle** **were** **demanding** **animals** **in** **Africa**. **They** **required** **water** **at** **least** **every** 24 **hours** **and** **large** tracts **of** grazing **grass** **if** herds **of** **any** **size** **were** **to** **be** maintained. **The** **secret** **was** **the** **careful** selection **of** grazing **land**, **especially** **in** **environments** **where** seasonal **rainfall** **led** **to** **marked** **differences** **in** graze **quality** **throughout** **the** **year**. **Even** **modest** **cattle** herds **required** **plenty** **of** **land** **and** considerable mobility. **To** **acquire** **such** **land** **often** **required** **moving** herds considerable **distances**, **even** **from** **summer** **to** **winter** pastures. **At** **the** **same** **time**, **the** **cattle** **owners** **had** **to** graze **their** stock **in** tsetse-**fly**-**free** **areas**. **The** **only** **protection** **against** **human** **and** **animal** **sleeping** **sickness**, **a** **disease** **carried** **by** **the** tsetse **fly**, **was** **to** **avoid** **settling** **or** **farming** **such** **areas**— **a** constraint severely **limiting** **the** **movements** **of** **cattle**-**owning** **farmers** **in** **eastern** **and** **central** **Africa**. **As** **a** **result**, **small** **cattle** herds **spread** **south** rapidly **in** **areas** **where** **they** **could** **be** grazed. **Long** **before** cereal **agriculture** **took** **hold** **far** **south** **of** **the** Sahara, **some** **hunter**-gatherer **groups** **in** **the** savanna woodlands **of** **eastern** **and** **southern** **Africa** may **have** **acquired** **cattle**, **and** **perhaps** **other** domesticated **animals**, **by** **gift** **exchange** **or** **through** raids **on** herding neighbors.

**Contrary** **to** **popular** **belief**, **there** **is** **no** **such** **phenomenon** **as** “**pure**” pastoralists, **a** **society** **that** subsists **on** **its** herds **alone**. **The** Saharan herders **who** **moved** southward **to** **escape** drought **were** **almost** **certainly** **also** cultivating sorghum, millet, **and** **other** tropical **rainfall** **crops**. **By** 1500 B.C., cereal **agriculture** **was** **widespread** **throughout** **the** savanna **belt** **south** **of** **the** Sahara. **Small** **farming** communities **dotted** **the** grasslands **and** **forest** margins **of** **eastern** **West** **Africa**, **all** **of** **them** **depending** **on** **what** **is** **called** shifting **agriculture**. **This** **form** **of** **agriculture** involved **clearing** woodland, **burning** **the** felled **brush** **over** **the** **cleared** **plot**, **mixing** **the** **ash** **into** **the** **soil**, **and** **then** cultivating **the** **prepared** **fields**. After **a** **few** **years**, **the** **soil** **was** exhausted, **so** **the** **farmer** **moved** **on**, **exploiting** **new** woodland **and** **leaving** **the** **abandoned** **fields** **to** **lie** fallow. Shifting **agriculture**, **often** **called** slash-**and**-**burn**, **was** highly adaptive **for** savanna **farmers** **without** plows, **for** **it** **allowed** cereal **farming** **with** **the** minimal expenditure **of** energy.

**The** **process** **of** clearance **and** **burning** may **have** **seemed** haphazard **to** **the** uninformed **eye**, **but** **it** **was** **not**. **Except** **in** favored **areas**, **such** **as** regularly inundated floodplains, tropical **Africa**’s **soils** **were** **of** **only** moderate **to** **low** fertility. **The** **art** **of** **farming** **was** **careful** **soil** selection, **that** **is**, **knowing** **which** **soils** **were** **light** **and** **easily** cultivable, **could** **be** readily **turned** **with** **small** hoes, **and** **would** maintain **their** fertility **over** **several** **years**’ **planting**, **for** cereal **crops** rapidly **remove** nitrogen **and** **other** nutrients **from** **the** **soil**. **Once** **it** **had** **taken** **hold**, slash-**and**-**burn** **agriculture** **expanded** **its** **frontiers** rapidly **as** **village** after **village** **took** **up** **new** **lands**, **moving** **forward** **so** rapidly **that** **one** **expert** **has** estimated **it** **took** **a** mere **two** **centuries** **to** **cover** 2,000 kilometers **from** **eastern** **to** **southern** **Africa**.

count: 237

# Official 29-Passage 01 Characteristics of Roman Pottery

**The** pottery **of** **ancient** Romans **is** remarkable **in** **several** **ways**. **The** **high** **quality** **of** Roman pottery **is** **very** **easy** **to** **appreciate** **when** **handling** **actual** **pieces** **of** tableware **or** **indeed** kitchenware **and** amphorae (**the** **large** **jars** **used** **throughout** **the** Mediterranean **for** **the** **transport** **and** **storage** **of** **liquids**, **such** **as** **wine** **and** **oil**). **However**, **it** **is** **impossible** **to** **do** **justice** **to** Roman **wares** **on** **the** **page**, **even** **when** **words** **can** **be** **backed** **up** **by** **photographs** **and** **drawings**. **Most** Roman pottery **is** **light** **and** **smooth** **to** **the** **touch** **and** **very** **tough**, **although**, **like** **all** pottery, **it** shatters **if** **dropped** **on** **a** **hard** **surface**. **It** **is** generally **made** **with** carefully **selected** **and** purified **clay**, worked **to** **thin**-**walled** **and** standardized **shapes** **on** **a** **fast** **wheel** **and** **fired** **in** **a** kiln (pottery oven) capable **of** ensuring **a** **consistent** **finish**. **With** handmade pottery, inevitably **there** **are** **slight** **differences** **between** individual vessels **of** **the** **same** **design** **and** occasional minor blemishes (flaws). **But** **what** **strikes** **the** **eye** **and** **the** **touch** **most** **immediately** **and** **most** powerfully **with** Roman pottery **is** **its** **consistent** **high** **quality**.

**This** **is** **not** **just** an aesthetic **consideration** **but** **also** **a** **practical** **one**. **These** vessels **are** **solid** (brittle, **but** **not** **fragile**), **they** **are** **pleasant** **and** **easy** **to** **handle** (**being** **light** **and** **smooth**), **and**, **with** **their** **hard** **and** **sometimes** glossy (**smooth** **and** shiny) **surfaces**, **they** **hold** **liquids** **well** **and** **are** **easy** **to** **wash**. Furthermore, **their** **regular** **and** standardized **shapes** **would** **have** **made** **them** **simple** **to** stack **and** **store**. **When** **people** **today** **are** **shown** **a** **very** **ordinary** Roman **pot** **and**, **in** **particular**, **are** **allowed** **to** **handle** **it**, **they** **often** **comment** **on** **how** **modern** **it** **looks** **and** **feels**, **and** **they** **need** **to** **be** **convinced** **of** **its** **true** **age**.

**As** impressive **as** **the** **quality** **of** Roman pottery **is** **its** sheer massive **quantity**. **When** **considering** **quantities**, **we** **would** ideally **like** **to** **have** **some** estimates **for** overall **production** **from** **particular** sites **of** pottery manufacture **and** **for** overall consumption **at** **specific** **settlements**. **Unfortunately**, **it** **is** **in** **the** **nature** **of** **the** archaeological **evidence**, **which** **is** **almost** invariably **only** **a** sample **of** **what** **once** **existed**, **that** **such** **figures** **will** **always** **be** elusive. **However**, **no** **one** **who** **has** **ever** worked **in** **the** **field** **would** **question** **the** abundance **of** Roman pottery, particularly **in** **the** Mediterranean region. **This** abundance **is** notable **in** Roman **settlements** (**especially** **urban** sites) **where** **the** labor **that** archaeologists **have** **to** **put** **into** **the** **washing** **and** **sorting** **of** potsherds (fragments **of** pottery) constitutes **a** **high** proportion **of** **the** **total** **work** **during** **the** **initial** phases **of** excavation.

**Only** rarely **can** **we** derive **any** “**real**” **quantities** **from** **deposits** **of** **broken** **pots**. **However**, **there** **is** **one** exceptional dump, **which** **does** **represent** **a** **very** **large** **part** **of** **the** site’s **total** **history** **of** consumption **and** **for** **which** an estimate **of** **quantity** **has** **been** **produced**. **On** **the** **left** **bank** **of** **the** Tiber **River** **in** Rome, **by** **one** **of** **the** **river** **ports** **of** **the** **ancient** **city**, **is** **a** substantial **hill** **some** 50 meters **high** **called** Monte Testaccio. **It** **is** **made** **up** entirely **of** **broken** **oil** amphorae, mainly **of** **the** **second** **and** **third** **centuries** **A**.D. **It** **has** **been** estimated **that** Monte Testaccio **contains** **the** **remains** **of** **some** 53 **million** amphorae, **in** **which** **around** 6,000 **million** liters **of** **oil** **were** **imported** **into** **the** **city** **from** overseas. **Imports** **into** imperial Rome **were** **supported** **by** **the** **full** **might** **of** **the** **state** **and** **were** **therefore** **quite** exceptional—**but** **the** **size** **of** **the** **operations** **at** Monte Testaccio, **and** **the** productivity **and** complexity **that** **lay** **behind** **them**, nonetheless cannot **fail** **to** **impress**. **This** **was** **a** **society** **with** similarities **to** **modern** **ones**—**moving** **goods** **on** **a** gigantic scale, manufacturing **high**-**quality** **containers** **to** **do** **so**, **and** occasionally, **as** **here**, **even** discarding **them** **on** delivery.

Roman pottery **was** **transported** **not** **only** **in** **large** **quantities** **but** **also** **over** substantial **distances**. **Many** Roman **pots**, **in** **particular** amphorae **and** **the** **fine** **wares** **designed** **for** **use** **at** **tables**, **could** **travel** **hundreds** **of** **miles**—**all** **over** **the** Mediterranean **and** **also** further afield. **But** **maps** **that** **show** **the** **various** **spots** **where** Roman pottery **of** **a** **particular** **type** **has** **been** **found** **tell** **only** **part** **of** **the** **story**. **What** **is** **more** significant **than** **any** geographical **spread** **is** **the** **access** **that** **different** **levels** **of** **society** **had** **to** **good**-**quality** **products**. **In** **all** **but** **the** remotest regions **of** **the** **empire**, Roman pottery **of** **a** **high** **standard** **is** **common** **at** **the** sites **of** humble **villages** **and** isolated farmsteads.

count: 237

# Official 20-Passage 01 Westward Migration

**The** **story** **of** **the** westward **movement** **of** **population** **in** **the** **United** **States** **is**, **in** **the** **main**, **the** **story** **of** **the** expansion **of** **American** **agriculture**—**of** **the** **development** **of** **new** **areas** **for** **the** **raising** **of** livestock **and** **the** cultivation **of** **wheat**, **corn**, **tobacco**, **and** **cotton**. After 1815 **improved** transportation enabled **more** **and** **more** **western** **farmers** **to** **escape** **a** **self**-sufficient **way** **of** **life** **and** **enter** **a** **national** **market** economy. **During** **periods** **when** commodity **prices** **were** **high**, **the** **rate** **of** westward migration **increased** spectacularly. “**Old** **America** **seemed** **to** **be** **breaking** **up** **and** **moving** westward,” **observed** an **English** **visitor** **in** 1817, **during** **the** **first** **great** **wave** **of** migration. Emigration **to** **the** **West** **reached** **a** peak **in** **the** 1830’s. Whereas **in** 1810 **only** **a** **seventh** **of** **the** **American** **people** **lived** **west** **of** **the** Appalachian **Mountains**, **by** 1840 **more** **than** **a** **third** **lived** **there**.

**Why** **were** **these** **hundreds** **of** **thousands** **of** **settlers**—**most** **of** **them** **farmers**, **some** **of** **them** artisans—**drawn** **away** **from** **the** **cleared** **fields** **and** established **cities** **and** **villages** **of** **the** **East**? **Certain** **characteristics** **of** **American** **society** **help** **to** **explain** **this** remarkable migration. **The** **European** **ancestors** **of** **some** Americans **had** **for** **centuries** **lived** **rooted** **to** **the** **same** **village** **or** **piece** **of** **land** **until** **some** **religious**, **political**, **or** economic crisis uprooted **them** **and** **drove** **them** **across** **the** **Atlantic**. **Many** **of** **those** **who** **experienced** **this** **sharp** **break** thereafter **lacked** **the** **ties** **that** **had** **bound** **them** **and** **their** **ancestors** **to** **a** **single** **place**. Moreover, **European** **society** **was** relatively stratified; **occupation** **and** **social** **status** **were** inherited. **In** **American** **society**, **however**, **the** **class** structure **was** **less** **rigid**; **some** **people** **changed** **occupations** **easily** **and** **believed** **it** **was** **their** **duty** **to** **improve** **their** **social** **and** economic **position**. **As** **a** **result**, **many** Americans **were** an inveterately restless, rootless, **and** ambitious **people**. **Therefore**, **these** **social** traits **helped** **to** **produce** **the** nomadic **and** **daring** **settlers** **who** **kept** **pushing** westward **beyond** **the** fringes **of** **settlement**. **In** **addition**, **there** **were** **other** immigrants **who** migrated **west** **in** **search** **of** **new** **homes**, **material** **success**, **and** **better** **lives**.

**The** **West** **had** **plenty** **of** **attractions**: **the** alluvial **river** **bottoms**, **the** fecund **soils** **of** **the** **rolling** **forest** **lands**, **the** **black** loams **of** **the** **prairies** **were** tempting **to** **New** **England** **farmers** **working** **their** rocky, sterile **land** **and** **to** southeastern **farmers** plagued **with** **soil** depletion **and** erosion. **In** 1820 **under** **a** **new** **land** **law**, **a** **farm** **could** **be** **bought** **for** $100. **The** **continued** proliferation **of** **banks** **made** **it** easier **for** **those** **without** **cash** **to** **negotiate** loans **in** **paper** **money**. **Western** **farmers** **borrowed** **with** **the** **confident** **expectation** **that** **the** **expanding** economy **would** **keep** **farm** **prices** **high**, **thus** **making** **it** **easy** **to** repay loans **when** **they** **fell** **due**.

Transportation **was** **becoming** **less** **of** **a** **problem** **for** **those** **who** **wished** **to** **move** **west** **and** **for** **those** **who** **had** **farm** **surpluses** **to** **send** **to** **market**. Prior **to** 1815, **western** **farmers** **who** **did** **not** **live** **on** navigable waterways **were** **connected** **to** **them** **only** **by** **dirt** **roads** **and** **mountain** trails. Livestock **could** **be** **driven** **across** **the** **mountains**, **but** **the** **cost** **of** **transporting** bulky **grains** **in** **this** fashion **was** **several** **times** greater **than** **their** **value** **in** **eastern** **markets**. **The** **first** **step** **toward** an improvement **of** **western** transportation **was** **the** **construction** **of** turnpikes. **These** **roads** **made** **possible** **a** reduction **in** transportation **costs** **and** **thus** stimulated **the** commercialization **of** **agriculture** **along** **their** routes.

**Two** **other** **developments** presaged **the** **end** **of** **the** era **of** turnpikes **and** **started** **a** transportation **revolution** **that** **resulted** **in** **increased** regional specialization **and** **the** **growth** **of** **a** **national** **market** economy. **First** **came** **the** steamboat; **although** flatboats **and** keelboats **continued** **to** **be** **important** **until** **the** 1850’s, steamboats **eventually** superseded **all** **other** craft **in** **the** **carrying** **of** **passengers** **and** freight. Steamboats **were** **not** **only** faster **but** **also** **transported** upriver freight **for** **about** **one** tenth **of** **what** **it** **had** previously **cost** **on** **hand**-propelled keelboats. **Next** **came** **the** Erie **Canal**, an enormous **project** **in** **its** **day**, spanning **about** 350 **miles**. After **the** **canal** **went** **into** **operation**, **the** **cost** **per** **mile** **of** **transporting** **a** **ton** **of** freight **from** Buffalo **to** **New York** York **City** **declined** **from** **nearly** 20 **cents** **to** **less** **than** 1 **cent**. **Eventually**, **the** **western** **states** diverted **much** **of** **their** **produce** **from** **the** **rivers** **to** **the** Erie **Canal**, **a** shorter route **to** **eastern** **markets**.

count: 237

# Official 39-Passage 03 Forest Fire Suppression

**Forest** **fires** **have** recently **increased** **in** intensity **and** extent **in** **some** **forest** **types** **throughout** **the** **western** **United** **States**. **This** **recent** **increase** **in** **fires** **has** **resulted** **partly** **from** **climate** **change** (**the** **recent** **trend** **toward** **hot**, **dry** **summers**) **and** **partly** **from** **human** **activities**, **for** complicated **reasons** **that** foresters **came** increasingly **to** **understand** **about** 30 **years** **ago** **but** **whose** **relative** **importance** **is** **still** **debated**. **One** factor **is** **the** **direct** **effect** **of** logging, **which** **often** **turns** **a** **forest** **into** **something** approximating **a** **huge** **pile** **of** kindling (**wood** **for** **burning**): **the** **ground** **in** **a** logged **forest** may **remain** **covered** **with** **branches** **and** treetops, **left** **behind** **when** **the** **valuable** **trunks** **are** carted **away**; **a** dense **growth** **of** **new** vegetation **springs** **up**, further **increasing** **the** **forest**’s **fuel** **loads**; **and** **the** **trees** logged **and** **removed** **are** **of** **course** **the** biggest **and** **most** **fire**-resistant individuals, **leaving** **behind** smaller **and** **more** flammable **trees**.

**Another** factor **is** **that** **the** **United** **States** **Forest** **Service** **in** **the** **first** **decade** **of** **the** 1900s **adopted** **the** **policy** **of** **fire** suppression (**attempting** **to** **put** **out** **forest** **fires**) **for** **the** **obvious** **reason** **that** **it** **did** **not** **want** **valuable** timber **to** **go** **up** **in** **smoke**, **or** **people**’s **homes** **and** **lives** **to** **be** threatened. **The** **Forest** **Service**’s **announced** **goal** **became** “**Put** **out** **every** **forest** **fire** **by** 10:00 **A**.M. **on** **the** **morning** after **the** **day** **when** **it** **is** **first** **reported**.” **Firefighters** **became** **much** **more** **successful** **at** **achieving** **that** **goal** after 1945, **thanks** **to** **improved** firefighting **technology**. **For** **a** **few** **decades** **the** **amount** **of** **land** **burnt** annually **decreased** **by** 80 **percent**. **That** **happy** **situation** **began** **to** **change** **in** **the** 1980s, **due** **to** **the** **increasing** frequency **of** **large** **forest** **fires** **that** **were** essentially **impossible** **to** extinguish **unless** **rain** **and** **low** **winds** **combined** **to** **help**.**People** **began** **to** realize **that** **the** **United** **States** federal **government**’s **fire**-suppression **policy** **was** **contributing** **to** **those** **big** **fires** **and** **that** **natural** **fires** **caused** **by** **lightning** **had** previously **played** an **important** **role** **in** maintaining **forest** structure.

**The** **natural** **role** **of** **fire** varies **with** **altitude**, **tree** species, **and** **forest** **type**. **To** **take** Montana’s **low**-**altitude** ponderosa **pine** **forest** **as** an **example**, historical **records**, **plus** **counts** **of** **annual** **tree** **rings** **and** datable **fire** **scars** **on** **tree** stumps, demonstrated **that** **a** ponderosa **pine** **forest** **experiences** **a** **lightning**-**lit** **fire** **about** **once** **a** **decade** **under** **natural** **conditions** (i.e., **before** **fire** suppression **began** **around** 1910 **and** **became** effective after 1945). **The** **mature** ponderosa **trees** **have** **bark** **two** **inches** **thick** **and** **are** relatively resistant **to** **fire**, **which** **instead** **burns** **out** **the** understory—**the** lower layer—**of** **fire**-**sensitive** Douglas fir seedlings **that** **have** **grown** **up** **since** **the** previous **fire**. **But** after **only** **a** **decade**’s **growth** **until** **the** **next** **fire**, **those** **young** seedling **plants** **are** **still** **too** **low** **for** **fire** **to** **spread** **from** **them** **into** **the** crowns **of** **the** ponderosa **pine** **trees**. Hence **the** **fire** **remains** confined **to** **the** **ground** **and** understory. **As** **a** **result**, **many** **natural** ponderosa **pine** **forests** **have** **a** parklike **appearance**, **with** **low** **fuel** **loads**, **big** **trees** **spaced** **apart**, **and** **a** relatively **clear** understory.

**However**, loggers **concentrated** **on** **removing** **those** **big**, **old**, **valuable**, **fire**-resistant ponderosa **pines**, **while** **fire** suppression **for** **decades** **let** **the** understory **fill** **up** **with** Douglas fir saplings **that** **would** **in** **turn** **become** **valuable** **when** **full**-**grown**. **Tree** densities **increased** **from** 30 **to** 200 **trees** **per** **acre**, **the** **forest**’s **fuel** **load** **increased** **by** **a** factor **of** 6, **and** **the** **government** repeatedly **failed** **to** **appropriate** **money** **to** **thin** **out** **the** saplings. **When** **a** **fire** finally **does** **start** **in** **a** sapling-**choked** **forest**, **whether** **due** **to** **lightning** **or** **human** carelessness **or** (regrettably **often**) intentional arson, **the** dense, **tall** saplings (**young** **trees**) may **become** **a** **ladder** **that** **allows** **the** **fire** **to** **jump** **into** **the** crowns **of** **the** **trees**. **The** **outcome** **is** **sometimes** an unstoppable inferno.

Foresters **now** identify **the** biggest **problem** **in** **managing** **Western** **forests** **as** **what** **to** **do** **with** **those** **increased** **fuel** **loads** **that** **built** **up** **during** **the** previous **half** **century** **of** effective **fire** suppression. **In** **the** wetter **eastern** **United** **States**, **dead** **trees** **rot** **away** **more** quickly **than** **in** **the** **drier** **West**, **where** **more** **dead** **trees** persist **like** giant matchsticks. **In** an ideal **world**, **the** **Forest** **Service** **would** **manage** **and** restore **the** **forests**, **thin** **them** **out**, **and** **remove** **the** dense understory **by** **cutting** **or** **by** **controlled** **small** **fires**. **But** **no** **politician** **or** voter **wants** **to** **spend** **what** **it** **would** **cost** **to** **do** **that**.

count: 236

# Official 18-Passage 02 The mystery of yawning

**According to** **conventional** **theory**, **yawning** **takes** **place** **when** **people** **are** **bored** **or** **sleepy** **and** **serves** **the** **function** **of** **increasing** alertness **by** reversing, **through** deeper **breathing**, **the** **drop** **in** **blood** **oxygen** **levels** **that** **are** **caused** **by** **the** **shallow** **breathing** **that** **accompanies** **lack** **of** **sleep** **or** boredom. **Unfortunately**, **the** **few** **scientific** investigations **of** **yawning** **have** **failed** **to** **find** **any** **connection** **between** **how** **often** **someone** **yawns** **and** **how** **much** **sleep** **they** **have** **had** **or** **how** **tired** **they** **are**. **About** **the** closest **any** **research** **has** **come** **to** **supporting** **the** tiredness **theory** **is** **to** **confirm** **that** **adults** **yawn** **more** **often** **on** **weekdays** **than** **on** **weekends**, **and** **that** **school** **children** **yawn** **more** frequently **in** **their** **first** **year** **at** **primary school** **than** **they** **do** **in** **kindergarten**.

**Another** flaw **of** **the** tiredness **theory** **is** **that** **yawning** **does** **not** **raise** alertness **or** physiological **activity**, **as** **the** **theory** **would** **predict**. **When** researchers **measured** **the** **heart** **rate**, muscle **tension** **and** **skin** conductance **of** **people** **before**, **during**, **and** after **yawning**, **they** **did** detect **some** **changes** **in** **skin** conductance **following** **yawning**, indicating **a** **slight** **increase** **in** physiological **activity**. **However**, **similar** **changes** **occurred** **when** **the** **subjects** **were** **asked** **simply** **to** **open** **their** **mouths** **or** **to** **breathe** **deeply**. **Yawning** **did** **nothing** **special** **to** **their** **state** **of** physiological **activity**. **Experiments** **have** **also** **cast** **serious** **doubt** **on** **the** **belief** **that** **yawning** **is** triggered **by** **a** **drop** **in** **blood** **oxygen** **or** **a** **rise** **in** **blood** **carbon** **dioxide**. **Volunteers** **were** **told** **to** **think** **about** **yawning** **while** **they** **breathed** **either** **normal** **air**, **pure** **oxygen**, **or** an **air** **mixture** **with** an **above**-**normal** **level** **of** **carbon** **dioxide**. **If** **the** **theory** **was** **correct**, **breathing** **air** **with** **extra** **carbon** **dioxide** **should** **have** triggered **yawning**, **while** **breathing** **pure** **oxygen** **should** **have** suppressed **yawning**. **In** **fact**, **neither** **condition** **made** **any** **difference** **to** **the** frequency **of** **yawning**, **which** **remained** **constant** **at** **about** 24 **yawns** **per** **hour**. **Another** **experiment** demonstrated **that** **physical** **exercise**, **which** **was** sufficiently vigorous **to** **double** **the** **rate** **of** **breathing**, **had** **no** **effect** **on** **the** frequency **of** **yawning**. **Again**, **the** implication **is** **that** **yawning** **has** **little** **or** **nothing** **to** **do** **with** **oxygen**.

**A** completely **different** **theory** **holds** **that** **yawning** **assists** **in** **the** **physical** **development** **of** **the** **lungs** **early** **in** **life**, **but** **has** **no** **remaining** biological **function** **in** **adults**. **It** **has** **been** **suggested** **that** **yawning** **and** hiccupping **might** **serve** **to** **clear** **out** **the** fetus’s airways. **The** **lungs** **of** **a** fetus secrete **a** **liquid** **that** **mixes** **with** **its** **mother**’s amniotic fluid. **Babies** **with** congenital blockages **that** **prevent** **this** fluid **from** **escaping** **from** **their** **lungs** **are** **sometimes** **born** **with** deformed **lungs**. **It** **might** **be** **that** **yawning** **helps** **to** **clear** **out** **the** **lungs** **by** periodically lowering **the** **pressure** **in** **them**. **According to** **this** **theory**, **yawning** **in** **adults** **is** **just** **a** developmental fossil **with** **no** biological **function**. **But**, **while** **accepting** **that** **not** **everything** **in** **life** **can** **be** **explained** **by** Darwinian **evolution**, **there** **are** **sound** **reasons** **for** **being** skeptical **of** **theories** **like** **this** **one**, **which** **avoid** **the** issue **of** **what** **yawning** **does** **for** **adults**. **Yawning** **is** distracting, **consumes** energy **and** **takes** **time**. **It** **is** **almost** **certainly** **doing** **something** significant **in** **adults** **as** **well** **as** **in** fetuses. **What** **could** **it** **be**?

**The** empirical **evidence**, **such** **as** **it** **is**, **suggests** an **altogether** **different** **function** **for** **yawning**—namely, **that** **yawning** **prepares** us **for** **a** **change** **in** **activity** **level**. **Support** **for** **this** **theory** **came** **from** **a** **study** **of** **yawning** behavior **in** **everyday** **life**. **Volunteers** **wore** **wrist**-mounted devices **that** automatically **recorded** **their** **physical** **activity** **for** **up** **to** **two** **weeks**; **the** **volunteers** **also** **recorded** **their** **yawns** **by** **pressing** **a** **button** **on** **the** device **each** **time** **they** **yawned**. **The** **data** **showed** **that** **yawning** **tended** **to** **occur** **about** 15 **minutes** **before** **a** **period** **of** **increased** behavioral **activity**. **Yawning** **bore** **no** **relationship** **to** **sleep** **patterns**, **however**. **This** accords **with** anecdotal **evidence** **that** **people** **often** **yawn** **in** **situations** **where** **they** **are** **neither** **tired** **nor** **bored**, **but** **are** **preparing** **for** impending **mental** **and** **physical** **activity**. **Such** **yawning** **is** **often** **referred** **to** **as** “incongruous” **because** **it** **seems** **out** **of** **place**, **at** **least** **on** **the** tiredness **view**: **soldiers** **yawning** **before** combat, **musicians** **yawning** **before** **performing**, **and** **athletes** **yawning** **before** **competing**. **Their** **yawning** **seems** **to** **have** **nothing** **to** **do** **with** sleepiness **or** boredom—**quite** **the** reverse—**but** **it** **does** precede **a** **change** **in** **activity** **level**.

count: 234

# Official 34-Passage 02 Islamic Art and the Book

**The** **arts** **of** **the** Islamic **book**, **such** **as** calligraphy **and** decorative **drawing**, **developed** **during** **A**.D. 900 **to** 1500, **and** luxury **books** **are** **some** **of** **the** **most** **characteristic** **examples** **of** Islamic **art** **produced** **in** **this** **period**. **This** **came** **about** **from** **two** **major** **developments**: **paper** **became** **common**, **replacing** parchment **as** **the** **major** **medium** **for** **writing**, **and** **rounded** scripts **were** regularized **and** **perfected** **so** **that** **they** **replaced** **the** angular scripts **of** **the** previous **period**, **which** **because** **of** **their** angularity **were** uneven **in** **height**.**Books** **became** **major** **vehicles** **for** artistic **expression**, **and** **the** **artists** **who** **produced** **them**, notably calligraphers **and** **painters**, **enjoyed** **high** **status**, **and** **their** workshops **were** **often** **sponsored** **by** princes **and** **their** **courts**. **Before** **A**.D. 900, manuscripts **of** **the** Koran (**the** **book** **containing** **the** teachings **of** **the** Islamic **religion**) **seem** **to** **have** **been** **the** **most** **common** **type** **of** **book** **produced** **and** **decorated**, **but** after **that** **date** **a** **wide** **range** **of** **books** **were** **produced** **for** **a** **broad** spectrum **of** patrons. **These** **continued** **to** **include**, **of** **course**, manuscripts **of** **the** Koran, **which** **every** Muslim **wanted** **to** **read**, **but** **scientific** **works**, **histories**, romances, **and** epic **and** lyric poetry **were** **also** **copied** **in** **fine** **handwriting** **and** **decorated** **with** **beautiful** illustrations. **Most** **were** **made** **for** **sale** **on** **the** **open** **market**, **and** **cities** boasted **special** souks (**markets**) **where** **books** **were** **bought** **and** **sold**. **The** mosque **of** Marrakech **in** Morocco **is** **known** **as** **the** Kutubiyya, **or** Booksellers’ Mosque, after **the** adjacent **market**. **Some** **of** **the** **most** luxurious **books** **were** **specific** commissions **made** **at** **the** **order** **of** **a** **particular** prince **and** **signed** **by** **the** calligrapher **and** decorator.

Papermaking **had** **been** **introduced** **to** **the** Islamic **lands** **from** **China** **in** **the** **eighth** **century**. **It** **has** **been** **said** **that** **Chinese** papermakers **were** **among** **the** **prisoners** captured **in** **a** **battle** **fought** **near** Samarqand **between** **the** **Chinese** **and** **the** Muslims **in** 751, **and** **the** **technique** **of** papermaking—**in** **which** cellulose pulp extracted **from** **any** **of** **several** **plants** **is** **first** suspended **in** **water**, **caught** **on** **a** **fine** **screen**, **and** **then** **dried** **into** **flexible** **sheets**—slowly **spread** westward. **Within** **fifty** **years**, **the** **government** **in** Baghdad **was** **using** **paper** **for** **documents**. **Writing** **in** **ink** **on** **paper**, **unlike** parchment, **could** **not** **easily** **be** erased, **and** **therefore** **paper** **had** **the** **advantage** **that** **it** **was** **difficult** **to** alter **what** **was** **written** **on** **it**. Papermaking **spread** quickly **to** **Egypt**—**and** **eventually** **to** Sicily **and** **Spain**—**but** **it** **was** **several** **centuries** **before** **paper** supplanted parchment **for** **copies** **of** **the** Koran, **probably** **because** **of** **the** **conservative** **nature** **of** **religious** **art** **and** **its** practitioners. **In** **western** Islamic **lands**, parchment **continued** **to** **be** **used** **for** manuscripts **of** **the** Koran **throughout** **this** **period**.

**The** **introduction** **of** **paper** spurred **a** conceptual **revolution** **whose** **consequences** **have** barely **been** **explored**. **Although** **paper** **was** **never** **as** **cheap** **as** **it** **has** **become** **today**, **it** **was** **far** **less** **expensive** **than** parchment, **and** **therefore** **more** **people** **could** **afford** **to** **buy** **books**. **Paper** **is** thinner **than** parchment, **so** **more** **pages** **could** **be** enclosed **within** **a** **single** volume. **At** **first**, **paper** **was** **made** **in** relatively **small** **sheets** **that** **were** **pasted** **together**, **but** **by** **the** **beginning** **of** **the** fourteenth **century**, **very** **large** **sheets**—**as** **much** **as** **a** meter **across**—**were** **available**. **These** **large** **sheets** **meant** **that** calligraphers **and** **artists** **had** **more** **space** **on** **which** **to** **work**. **Paintings** **became** **more** complicated, **giving** **the** **artist** greater opportunities **to** depict **space** **or** emotion. **The** **increased** availability **of** **paper**, particularly after 1250, **encouraged** **people** **to** **develop** **systems** **of** representation, **such** **as** architectural **plans** **and** **drawings**. **This** **in** **turn** **allowed** **the** **easy** transfer **of** artistic **ideas** **and** motifs **over** **great** **distances**, **from** **one** **medium** **to** **another**, **and** **in** **a** **different** scale **in** **ways** **that** **had** **been** **difficult**, **if** **not** **impossible**, **in** **the** previous **period**.

**Rounded** **styles** **of** **Arabic** **handwriting** **had** **long** **been** **used** **for** correspondence **and** **documents** **alongside** **the** formal angular scripts **used** **for** inscriptions **and** manuscripts **of** **the** Koran. **Around** **the** **year** 900, Ibn Muqla, **who** **was** **a** **secretary** **and** vizier **at** **the** Abbasid **court** **in** Baghdad, **developed** **a** **system** **of** proportioned **writing**. **He** standardized **the** **length** **of** alif, **the** **first** **letter** **of** **the** **Arabic** **alphabet**, **and** **then** **determined** **what** **the** **size** **and** **shape** **of** **all** **other** **letters** **should** **be**, **based** **on** **the** alif. **Eventually**, **six** **round** **forms** **of** **handwriting**, composed **of** **three** **pairs** **of** **big** **and** **little** scripts **known** collectively **as** **the** **Six** **Pens**, **became** **the** **standard** repertory **of** **every** calligrapher.

count: 234

# Official 33-Passage 03 The First Civilizations

**Evidence** **suggests** **that** an **important** stimulus **behind** **the** **rise** **of** **early** **civilizations** **was** **the** **development** **of** **settled** **agriculture**, **which** unleashed **a** series **of** **changes** **in** **the** **organization** **of** **human** communities **that** culminated **in** **the** **rise** **of** **large** **ancient** **empires**.

**The** **exact** **time** **and** **place** **that** **crops** **were** **first** cultivated successfully **is** **uncertain**. **Many** prehistorians **believe** **that** **farming** may **have** emerged independently **in** **several** **different** **areas** **of** **the** **world** **when** **small** communities, **driven** **by** **increasing** **population** **and** **a** **decline** **in** **available** **food** resources, **began** **to** **plant** **seeds** **in** **the** **ground** **in** an **effort** **to** **guarantee** **their** **survival**. **The** **first** **farmers**, **who** may **have** **lived** **as** **long** **as** 10,000 **years** **ago**, undoubtedly **used** **simple** **techniques** **and** **still** **relied** primarily **on** **other** **forms** **of** **food** **production**, **such** **as** **hunting**, foraging, **or** pastoralism. **The** **real** **breakthrough** **took** **place** **when** **farmers** **began** **to** cultivate **crops** **along** **the** floodplains **of** **river** **systems**. **The** **advantage** **was** **that** **crops** **grown** **in** **such** **areas** **were** **not** **as** dependent **on** **rainfall** **and** **therefore** **produced** **a** **more** **reliable** **harvest**. An additional **benefit** **was** **that** **the** sediment **carried** **by** **the** **river** **waters** **deposited** nutrients **in** **the** **soil**, **thus** enabling **the** **farmer** **to** cultivate **a** **single** **plot** **of** **ground** **for** **many** **years** **without** **moving** **to** **a** **new** location. **Thus**, **the** **first** **truly** sedentary (**that** **is**, nonmigratory) **societies** **were** **born**. **As** **time** **went** **on**, **such** communities **gradually** **learned** **how** **to** **direct** **the** **flow** **of** **water** **to** enhance **the** productive capacity **of** **the** **land**, **while** **the** **introduction** **of** **the** **iron** plow **eventually** **led** **to** **the** cultivation **of** **heavy** **soils** **not** previously susceptible **to** **agriculture**.

**The** **spread** **of** **this** **river** **valley** **agriculture** **in** **various** **parts** **of** **Asia** **and** **Africa** **was** **the** decisive factor **in** **the** **rise** **of** **the** **first** **civilizations**. **The** **increase** **in** **food** **production** **in** **these** regions **led** **to** **a** significant **growth** **in** **population**, **while** **efforts** **to** **control** **the** **flow** **of** **water** **to** maximize **the** **irrigation** **of** cultivated **areas** **and** **to** **protect** **the** **local** inhabitants **from** hostile **forces** **outside** **the** community provoked **the** **first** **steps** **toward** cooperative **activities** **on** **a** **large** scale. **The** **need** **to** oversee **the** **entire** **process** **brought** **about** **the** emergence **of** an elite **that** **was** **eventually** **transformed** **into** **a** **government**.

**The** **first** **clear** **steps** **in** **the** **rise** **of** **the** **first** **civilizations** **took** **place** **in** **the** **fourth** **and** **third** millennia B.C. **in** Mesopotamia, **northern** **Africa**, **India**, **and** **China**. **How** **the** **first** **governments** **took** **shape** **in** **these** **areas** **is** **not** **certain**, **but** anthropologists **studying** **the** **evolution** **of** **human** communities **in** **various** **parts** **of** **the** **world** **have** **discovered** **that** **one** **common** **stage** **in** **the** **process** **is** **the** emergence **of** **what** **are** **called** “**big** **men**” **within** **a** **single** **village** **or** **a** **collection** **of** **villages**. **By** **means** **of** **their** military prowess, dominant personalities, **or** **political** **talent**, **these** **people** **gradually** emerge **as** **the** **leaders** **of** **that** community. **In** **time**, **the** “**big** **men**” **become** formal **symbols** **of** **authority** **and** **pass** **on** **that** **authority** **to** **others** **within** **their** **own** **family**. **As** **the** communities **continue** **to** **grow** **in** **size** **and** **material** **wealth**, **the** “**big** **men**” **assume** hereditary **status**, **and** **their** allies **and** **family** **members** **are** **transformed** **into** **a** hereditary monarchy.

**The** **appearance** **of** **these** sedentary **societies** **had** **a** **major** impact **on** **the** **social** **organizations**, **religious** **beliefs**, **and** **way** **of** **life** **of** **the** **peoples** **living** **within** **their** **boundaries**. **With** **the** **increase** **in** **population** **and** **the** **development** **of** centralized **authority** **came** **the** emergence **of** **the** **cities**. **While** **some** **of** **these** **urban** centers **were** identified **with** **a** **particular** economic **function**, **such** **as** proximity **to** **gold** **or** **iron** **deposits** **or** **a** strategic location **on** **a** **major** **trade** route, **others** **served** primarily **as** administrative centers **or** **the** site **of** **temples** **for** **the** **official** cult **or** **other** ritual observances. **Within** **these** **cities**, **new** **forms** **of** livelihood **appeared** **to** **satisfy** **the** **growing** **need** **for** **social** **services** **and** consumer **goods**. **Some** **people** **became** artisans **or** **merchants**, **while** **others** **became** warriors, **scholars**, **or** priests. **In** **some** **cases**, **the** **physical** **division** **within** **the** **first** **cities** **reflected** **the** **strict** hierarchical **character** **of** **the** **society** **as** **a** **whole**, **with** **a** **royal** **palace** **surrounded** **by** an imposing **wall** **and** **separate** **from** **the** remainder **of** **the** **urban** **population**. **In** **other** instances, **such** **as** **the** Indus **River** **Valley**, **the** **cities** **lacked** **a** **royal** precinct **and** **the** ostentatious **palaces** **that** **marked** **their** **contemporaries** elsewhere.

count: 233

# Official 36-Passage 02 Early Ideas about Deep-sea Biology

**In** 1841 Edward Forbes **was** **offered** **the** **chance** **to** **serve** **as** naturalist **aboard** HMS Beacon, an **English** **Royal** **Navy** **ship** assigned **to** survey **the** Aegean **Sea**. **For** **a** **year** **and** **a** **half** **the** Beacon crisscrossed **the** Aegean **waters**. **During** **that** **time** Forbes **was** **able** **to** **drag** **his** **small**, triangular dredge—**a** **tool** **with** **a** **leather** **net** **for** capturing **creatures** **along** **the** **sea** **bottom**—**at** **a** **hundred** locations, **at** **depths** **ranging** **from** 6 **to** 1,380 **feet**. **He** **collected** **hundreds** **of** **different** species **of** **animals**, **and** **he** **saw** **that** **they** **were** **distributed** **in** **eight** **different** **depth** **zones**, **each** **containing** **its** **own** distinct assemblage **of** **animal** **life**, **the** **way** **zones** **of** elevation **on** **the** **side** **of** **a** **mountain** **are** populated **by** distinct **sets** **of** **plants**.

Forbes **also** **thought** **he** **saw**, **as** **he** **later** **told** **the British** **Association**, **that** “**the** **number** **of** species **and** individuals diminishes **as** **we** descend, **pointing** **to** **a** **zero** **in** **the** distribution **of** **animal** **life** **as** **yet** unvisited.” **This** **zero**, Forbes casually speculated—**he** **simply** extended **a** **line** **on** **his** **graph** **of** **animal** **number** versus **depth**—**probably** **began** **at** **a** **depth** **of** 1,800 **feet**. **Below** **that** **was** **the** **final** **zone** **in** Forbes’s scheme, **zone** **nine**, **a** **zone** **that** **covered** **most** **of** **the** **ocean** **floor** **and** **thus** **most** **of** **the** **solid** **surface** **of** **Earth**: Forbes **called** **this** **the** azoic **zone**, **where** **no** **animal**, **to** **say** **nothing** **of** **plants**, **could** **survive**.

Forbes’s azoic **zone** **was** entirely plausible **at** **the** **time**, **and** **it** **was** **certainly** **far** **from** **the** strangest **idea** **that** **was** **then** entertained **about** **the** **deep** **sea**. **In** **the** **first** **decade** **of** **the** nineteenth **century**, **a** **French** naturalist **named** François Péron **had** **sailed** **around** **the** **world** **measuring** **the** **temperature** **of** **the** **ocean**. **He** **found** **that** **the** deeper **the** **water**, **the** colder **it** **got**, **and** **he** **concluded** **that** **the** seafloor **was** **covered** **with** **a** **thick** layer **of** **ice**. Péron **ignored** **the** **fact** **that** **water** **expands** **when** **it** **freezes** **and** **that** **ice** **therefore** **floats**. **A** **more** **popular** **belief** **at** **the** **time** **was** **that** **water** **at** **great** **depth** **would** **be** compressed **to** **such** **a** density **that** **nothing** **could** **sink** **through** **it**. **This** **ignored** **the** **fact** **that** **water** **is** **all** **but** incompressible. **But** **even** **the** **more** sensible naturalists **of** **the** **day** **were** **guilty** **of** **a** **similar** misconception. **They** **imagined** **the** **deep** **sea** **as** **being** **filled** **with** an unmoving **and** undisturbable **pool** **of** **cold**, dense **water**. **In** **reality** **the** **deep** **is** **always** **being** **refreshed** **by** **cold** **water** **sinking** **from** **above**.

**The** **central** implication **of** **all** **these** misconceptions **was** **that** **nothing** **could** **live** **in** **the** abyss (**deep**), **just** **as** Forbes’s observations **seemed** **to** indicate. **But** Forbes erred **in** **two** **ways**. **One** **was** **the** **particular** **study** site **he** **happened** **to** **use** **as** **a** springboard **for** **his** **sweeping** postulate **of** **a** lifeless abyss. **Although** **the** Aegean **had** **been** **the** **birthplace** **of** marine **biology**, **its** **depths** **are** **now** **known** **to** **be** exceptionally **lacking** **in** **animal** diversity. Moreover, **through** **no** **fault** **of** **his** **own**, Forbes **was** **not** particularly **successful** **at** sampling **such** **life** **as** **did** **exist** **at** **the** **bottom** **of** **the** Aegean. **It** **was** **his** dredge **that** **was** inadequate. **Its** **opening** **was** **so** **small** **and** **the** **holes** **in** **the** **net** **so** **large** **that** **the** dredge inevitably **missed** **animals**. **Many** **of** **those** **it** **did** **catch** must **have** **poured** **out** **of** **its** **open** **mouth** **when** Forbes reeled **it** **in**. **His** azoic **zone**, **then**, **was** **a** plausible **but** **wild** extrapolation **from** **pioneering** **but** feeble **data**.

**As** **it** **turned** **out**, **the** **existence** **of** **the** azoic **zone** **had** **been** disproved **even** **before** Forbes **suggested** **it**, **and** **the** **theory** **continued** **to** **be** **contradicted** regularly **throughout** **its** **long** **and** influential **life**. **Searching** **for** **the** **Northwest** **Passage** **from** **the** **Atlantic** **to** **the** **Pacific** **in** 1818, **Sir** John Ross **had** lowered **his** “**deep**-**sea** clam”—**a** **sort** **of** bivalved sediment scoop—**into** **the** **waters** **of** Baffin **Bay** (an inlet **between** **the** **Atlantic** **and** **Arctic** **oceans**), **which** **he** **determined** **to** **be** **more** **than** **a** **thousand** fathoms **deep** **in** **some** **places**. **Modern** soundings indicate **he** overestimated **his** **depths** **by** **several** **hundred** fathoms, **but** **in** **any** **case** Ross’s clam **dove** **several** **times** deeper **than** Forbes’s dredge. **It** **brought** **back** **mud** laced **with** **worms**, **and** starfish **that** **had** entangled **themselves** **in** **the** **line** **at** **depths** **well** **below** **the** **supposed** **boundary** **of** **the** azoic **zone**.

count: 233

# Official 03-Passage 01 Architecture

**Architecture** **is** **the** **art** **and** **science** **of** **designing** structures **that** organize **and** enclose **space** **for** **practical** **and** symbolic **purposes**. **Because** **architecture** **grows** **out** **of** **human** **needs** **and** aspirations, **it** **clearly** **communicates** cultural **values**. **Of** **all** **the** **visual** **arts**, **architecture** **affects** **our** **lives** **most** directly **for** **it** **determines** **the** **character** **of** **the** **human** **environment** **in** **major** **ways**.

**Architecture** **is** **a** **three**-dimensional **form**. **It** utilizes **space**, **mass**, texture, **line**, **light**, **and** color. **To** **be** **architecture**, **a** **building** must **achieve** **a** **working** **harmony** **with** **a** **variety** **of** elements. **Humans** instinctively **seek** structures **that** **will** **shelter** **and** enhance **their** **way** **of** **life**. **It** **is** **the** **work** **of** **architects** **to** **create** **buildings** **that** **are** **not** **simply** **constructions** **but** **also** **offer** inspiration **and** **delight**. **Buildings** **contribute** **to** **human** **life** **when** **they** **provide** **shelter**, enrich **space**, complement **their** site, **suit** **the** **climate**, **and** **are** economically feasible. **The** client **who** **pays** **for** **the** **building** **and** defines **its** **function** **is** an **important** **member** **of** **the** architectural **team**. **The** mediocre **design** **of** **many** **contemporary** **buildings** **can** **be** traced **to** **both** clients **and** **architects**.

**In** **order** **for** **the** structure **to** **achieve** **the** **size** **and** **strength** **necessary** **to** **meet** **its** **purpose**, **architecture** **employs** **methods** **of** **support** **that**, **because** **they** **are** **based** **on** **physical** **laws**, **have** **changed** **little** **since** **people** **first** **discovered** **them**–**even** **while** **building** **materials** **have** **changed** dramatically. **The** **world**’s architectural structures **have** **also** **been** devised **in** **relation** **to** **the** objective limitations **of** **materials**. Structures **can** **be** **analyzed** **in** **terms** **of** **how** **they** **deal** **with** **downward** **forces** **created** **by** **gravity**. **They** **are** **designed** **to** withstand **the** **forces** **of** compression (**pushing** **together**), **tension** (**pulling** **apart**), **bending**, **or** **a** combination **of** **these** **in** **different** **parts** **of** **the** structure.

**Every** **development** **in** **architecture** **has** **been** **the** **result** **of** **major** technological **changes**. **Materials** **and** **methods** **of** **construction** **are** integral **parts** **of** **the** **design** **of** architectural structures. **In** earlier **times** **it** **was** **necessary** **to** **design** structural **systems** **suitable** **for** **the** **materials** **that** **were** **available**, **such** **as** **wood**, **stone**, **or** **brick**. **Today** **technology** **has** **progressed** **to** **the** **point** **where** **it** **is** **possible** **to** **invent** **new** **building** **materials** **to** **suit** **the** **type** **of** structure **desired**. Enormous **changes** **in** **materials** **and** **techniques** **of** **construction** **within** **the** **last** **few** **generations** **have** **made** **it** **possible** **to** enclose **space** **with** **much** greater **ease** **and** **speed** **and** **with** **a** **minimum** **of** **material**. **Progress** **in** **this** **area** **can** **be** **measured** **by** **the** **difference** **in** **weight** **between** **buildings** **built** **now** **and** **those** **of** comparable **size** **built** **one** **hundred** **years** **ago**.

**Modern** architectural **forms** generally **have** **three** **separate** **components** comparable **to** elements **of** **the** **human** body: **a** **supporting** skeleton **or** frame, an **outer** **skin** enclosing **the** interior **spaces**, **and** **equipment**, **similar** **to** **the** body’s **vital** **organs** **and** **systems**. **The** **equipment** **includes** plumbing, **electrical** **wiring**, **hot** **water**, **and** **air**-**conditioning**. **Of** **course** **in** **early** **architecture**–**such** **as** igloos **and** adobe structures–**there** **was** **no** **such** **equipment**, **and** **the** skeleton **and** **skin** **were** **often** **one**.

**Much** **of** **the** **world**’s **great** **architecture** **has** **been** **constructed** **of** **stone** **because** **of** **its** **beauty**, permanence, **and** availability. **In** **the** **past**, **whole** **cities** **grew** **from** **the** arduous **task** **of** **cutting** **and** **piling** **stone** **upon** **stone**. **Some** **of** **the** **world**’s finest **stone** **architecture** **can** **be** **seen** **in** **the** **ruins** **of** **the** **ancient** Inca **city** **of** Machu Picchu **high** **in** **the** **eastern** Andes **Mountains** **of** Peru. **The** doorways **and** **windows** **are** **made** **possible** **by** **placing** **over** **the** **open** **spaces** **thick** **stone** **beams** **that** **support** **the** **weight** **from** **above**. **A** structural **invention** **had** **to** **be** **made** **before** **the** **physical** limitations **of** **stone** **could** **be** **overcome** **and** **new** architectural **forms** **could** **be** **created**. **That** **invention** **was** **the** **arch**, **a** curved structure originally **made** **of** **separate** **stone** **or** **brick** segments. **The** **arch** **was** **used** **by** **the** **early** **cultures** **of** **the** Mediterranean **area** chiefly **for** **underground** drains, **but** **it** **was** **the** Romans **who** **first** **developed** **and** **used** **the** **arch** extensively **in** aboveground structures. Roman builders **perfected** **the** semicircular **arch** **made** **of** **separate** **blocks** **of** **stone**. **As** **a** **method** **of** spanning **space**, **the** **arch** **can** **support** greater **weight** **than** **a** horizontal **beam**. **It** **works** **in** compression **to** divert **the** **weight** **above** **it** **out** **to** **the** **sides**, **where** **the** **weight** **is** borne **by** **the** **vertical** elements **on** **either** **side** **of** **the** **arch**. **The** **arch** **is** **among** **the** **many** **important** structural **breakthroughs** **that** **have** characterized **architecture** **throughout** **the** **centuries**.

count: 233

# Official 10-Passage 01 Chinese Pottery

**China** **has** **one** **of** **the** **world**’s oldest continuous **civilizations**—despite invasions **and** occasional **foreign** **rule**. **A** **country** **as** **vast** **as** **China** **with** **so** **long**-**lasting** **a** **civilization** **has** **a** **complex** **social** **and** **visual** **history**, **within** **which** pottery **and** porcelain **play** **a** **major** **role**.

**The** **function** **and** **status** **of** ceramics **in** **China** varied **from** dynasty **to** dynasty, **so** **they** may **be** utilitarian, **burial**, **trade**, collectors’, **or** **even** ritual **objects**, **according to** **their** **quality** **and** **the** era **in** **which** **they** **were** **made**. **The** ceramics **fall** **into** **three** **broad** **types**—earthenware, stoneware, **and** porcelain—**for** vessels, architectural items **such** **as** **roof** tiles, **and** **modeled** **objects** **and** **figures**. **In** **addition**, **there** **was** an **important** **group** **of** **sculptures** **made** **for** **religious** **use**, **the** **majority** **of** **which** **were** **produced** **in** earthenware.

**The** earliest ceramics **were** **fired** **to** earthenware **temperatures**, **but** **as** **early** **as** **the** fifteenth **century** B.C., **high**-**temperature** stonewares **were** **being** **made** **with** glazed **surfaces**. **During** **the** **Six** **Dynasties** **period** (**A**.D. 265–589), kilns  **in** **north** **China** **were** **producing** **high**-**fired** ceramics **of** **good** **quality**. Whitewares **produced** **in** Hebei **and** Henan **provinces** **from** **the** **seventh** **to** **the** tenth **centuries** evolved **into** **the** highly **prized** porcelains **of** **the** **Song** dynasty (**A**.D. 960–1279), **long** **regarded** **as** **one** **of** **the** **high** **points** **in** **the** **history** **of** **China**’s ceramic **industry**. **The** **tradition** **of** **religious** **sculpture** extends **over** **most** historical **periods** **but** **is** **less** **clearly** delineated **than** **that** **of** stonewares **or** porcelains, **for** **it** embraces **the** **old** **custom** **of** earthenware **burial** ceramics **with** **later** **religious** images **and** architectural ornament. Ceramic **products** **also** **include** **lead**-glazed **tomb** **models** **of** **the** Han dynasty, **three**-color **lead**-glazed vessels **and** **figures** **of** **the** Tang dynasty, **and** Ming **three**-color **temple** ornaments, **in** **which** **the** motifs **were** **outlined** **in** **a** **raised** trail **of** **slip** , **as** **well** **as** **the** **many** **burial** ceramics **produced** **in** imitation **of** vessels **made** **in** **materials** **of** higher intrinsic **value**.

**Trade** **between** **the** **West** **and** **the** **settled** **and** prosperous **Chinese** dynasties **introduced** **new** **forms** **and** **different** **technologies**. **One** **of** **the** **most** **far**-**reaching** **examples** **is** **the** impact **of** **the** **fine** **ninth**-**century** **A**.D. **Chinese** porcelain **wares** **imported** **into** **the** **Arab** **world**. **So** **admired** **were** **these** **pieces** **that** **they** **encouraged** **the** **development** **of** earthenware **made** **in** imitation **of** porcelain **and** instigated **research** **into** **the** **method** **of** **their** manufacture. **From** **the** **Middle East** **East** **the** **Chinese** **acquired** **a** **blue** pigment—**a** purified **form** **of** cobalt oxide unobtainable **at** **that** **time** **in** **China**—**that** **contained** **only** **a** **low** **level** **of** manganese. Cobalt **ores** **found** **in** **China** **have** **a** **high** manganese **content**, **which** **produces** **a** **more** muted **blue**-gray color. **In** **the** seventeenth **century**, **the** **trading** **activities** **of** **the** Dutch **East** **India** **Company** **resulted** **in** **vast** **quantities** **of** **decorated** **Chinese** porcelain **being** **brought** **to** **Europe**, **which** stimulated **and** **influenced** **the** **work** **of** **a** **wide** **variety** **of** **wares**, notably Delft. **The** **Chinese** **themselves** **adapted** **many** **specific** vessel **forms** **from** **the** **West**, **such** **as** **bottles** **with** **long** spouts, **and** **designed** **a** **range** **of** decorative **patterns** **especially** **for** **the** **European** **market**.

**Just** **as** **painted** **designs** **on** **Greek** **pots** may **seem** **today** **to** **be** purely decorative, whereas **in** **fact** **they** **were** carefully **and** precisely worked **out** **so** **that** **at** **the** **time**, **their** **meaning** **was** **clear**, **so** **it** **is** **with** **Chinese** **pots**. **To** **twentieth**-**century** **eyes**, **Chinese** pottery may **appear** **merely** decorative, **yet** **to** **the** **Chinese** **the** **form** **of** **each** **object** **and** **its** adornment **had** **meaning** **and** **significance**. **The** dragon **represented** **the** **emperor**, **and** **the** phoenix, **the** empress; **the** pomegranate indicated fertility, **and** **a** **pair** **of** **fish**, **happiness**; mandarin **ducks** **stood** **for** wedded bliss; **the** **pine** **tree**, **peach**, **and** crane **are** emblems **of** **long** **life**; **and** **fish** leaping **from** **waves** indicated **success** **in** **the** **civil** **service** examinations. **Only** **when** **European** decorative **themes** **were** **introduced** **did** **these** **meanings** **become** obscured **or** **even** **lost**.

**From** **early** **times** **pots** **were** **used** **in** **both** **religious** **and** secular contexts. **The** imperial **court** commissioned **work** **and** **in** **the** Yuan dynasty (**A**.D. 1279–1368) an imperial ceramic **factory** **was** established **at** Jingdezhen. **Pots** **played** an **important** **part** **in** **some** **religious** **ceremonies**. **Long** **and** **often** lyrical **descriptions** **of** **the** **different** **types** **of** ware **exist** **that** **assist** **in** **classifying** **pots**, **although** **these** **sometimes** **confuse** an **already** **large** **and** complicated **picture**.

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  kilns: an enclosed oven **used** **to** **heat** **and** harden **clay** **objects**

**slip**: **a** **mixture** **of** **clay** **and** **water** **used** **to** **decorate** pottery

count: 231

# Official 43-Passage 03 The Empire of Alexander the Great

**In** 334 B.C. Alexander **the** **Great** **took** **his** **Greek** **armies** **to** **the** **east** **and** **in** **only** **a** **few** **years** **completed** **his** creation **of** an **empire** **out** **of** **much** **of** **southwest** **Asia**. **In** **the** **new** **empire**, **barriers** **to** **trade** **and** **the** **movement** **of** **peoples** **were** **removed**; **markets** **were** **put** **in** **touch** **with** **one** **another**. **In** **the** **next** **generation** **thousands** **of** **Greek** traders **and** artisans **would** **enter** **this** wider **world** **to** **seek** **their** **fortunes**. Alexander’s **actions** **had** **several** **important** **consequences** **for** **the** region occupied **by** **the** **empire**.

**The** **first** **of** **these** **was** **the** expansion **of** **Greek** **civilization** **throughout** **the** **Middle East** **East**. **Greek** **became** **the** **great** **international** **language**. **Towns** **and** **cities** **were** established **not** **only** **as** garrisons (military **posts**) **but** **as** centers **for** **the** diffusion **of** **Greek** **language**, **literature**, **and** **thought**, particularly **through** **libraries**, **as** **at** Antioch (**in** **modern** **Turkey**) **and** **the** **most** **famous** **of** **all**, **at** Alexandria **in** **Egypt**, **which** **would** **be** **the** finest **in** **the** **world** **for** **the** **next** **thousand** **years**.

**Second**, **this** internationalism **spelled** **the** **end** **of** **the** **classical** **Greek** **city**-**state**—**the** **unit** **of** **government** **in** **ancient** **Greece**—**and** **everything** **it** **stood** **for**. **Most** **city**-**states** **had** **been** **quite** **small** **in** **terms** **of** citizenry, **and** **this** **was** **considered** **to** **be** **a** **good** **thing**. **The** **focus** **of** **life** **was** **the** agora, **the** **open** marketplace **where** assemblies **could** **be** **held** **and** **where** issues **of** **the** **day**, **as** **well** **as** **more** **fundamental** **topics** **such** **as** **the** **purpose** **of** **government** **or** **the** **relationship** **between** **law** **and** **freedom**, **could** **be** **discussed** **and** **decisions** **made** **by** individuals **in** **person**. **The** philosopher Plato (428–348 B.C.) **felt** **that** **the** ideal **city**-**state** **should** **have** **about** 5,000 **citizens**, **because** **to** **the** Greeks **it** **was** **important** **that** **everyone** **in** **the** community **should** **know** **each** **other**. **In** **decision** **making**, **the** **whole** body **of** **citizens** **together** **would** **have** **the** **necessary** **knowledge** **in** **order** generally **to** **reach** **the** **right** **decision**, **even** **though** **the** individual **might** **not** **be** particularly qualified **to** **decide**. **The** philosopher Aristotle (384–322 B.C.), **who** **lived** **at** **a** **time** **when** **the** **city**-**state** **system** **was** **declining**, **believed** **that** **a** **political** entity **of** 100,000 **simply** **would** **not** **be** **able** **to** **govern** **itself**.

**This** implied **that** **the** **city**-**state** **was** **based** **on** **the** **idea** **that** **citizens** **were** **not** **specialists** **but** **had** multiple **interests** **and** **talents**—**each** **a** **so**-**called** jack-**of**-**all**-**trades** **who** **could** engage **in** **many** **areas** **of** **life** **and** **politics**. **It** implied **a** **respect** **for** **the** wholeness **of** **life** **and** **a** consequent **dislike** **of** specialization. **It** implied economic **and** military **self**-sufficiency. **But** **with** **the** **development** **of** **trade** **and** commerce **in** Alexander’s **empire** **came** **the** **growth** **of** **cities**; **it** **was** **no** longer **possible** **to** **be** **a** jack-**of**-**all**-**trades**. **One** **now** **had** **to** specialize, **and** **with** specialization **came** professionalism. **There** **were** **getting** **to** **be** **too** **many** **persons** **to** **know**; an **easily** observable community **of** **interests** **was** **being** **replaced** **by** **a** multiplicity **of** **interests**. **The** **city**-**state** **was** **simply** **too** “**small**-**time**.”

**Third**, **Greek** philosophy **was** **opened** **up** **to** **the** philosophy **and** **religion** **of** **the** **East**. **At** **the** peak **of** **the** **Greek** **city**-**state**, **religion** **played** an **important** **part**. **Its** **gods**—**such** **as** Zeus, **father** **of** **the** **gods**, **and** **his** **wife** Hera—**were** **thought** **of** **very** **much** **as** **being** **like** **human** **beings** **but** **with** superhuman **abilities**. **Their** worship **was** **linked** **to** **the** rituals **connected** **with** **one**’s **progress** **through** **life**—**birth**, **marriage**, **and** **death**—**and** **with** invoking **protection** **against** **danger**, **making** prophecies, **and** **promoting** healing, **rather** **than** **to** **any** code **of** behavior. **Nor** **was** **there** **much** **of** **a** **theory** **of** afterlife.

**Even** **before** Alexander’s **time**, **a** **life** **spent** **in** **the** **service** **of** **their** **city**-**state** **no** longer **seemed** ideal **to** Greeks. **The** Athenian philosopher Socrates (470–399 B.C.) **was** **the** **first** **person** **in** **Greece** **to** propose **a** morality **based** **on** individual **conscience** **rather** **than** **the** **demands** **of** **the** **state**, **and** **for** **this** **he** **was** **accused** **of** **not** **believing** **in** **the** **city**’s **gods** **and** **so** **corrupting** **the** **youth**, **and** **he** **was** **condemned** **to** **death**. **Greek** philosophy—**or** **even** **a** **focus** **on** **conscience**—**might** complement **religion** **but** **was** **no** **substitute** **for** **it**, **and** **this** **made** Greeks receptive **to** **the** **religious** **systems** **of** **the** **Middle East** **East**, **even** **if** **they** **never** **adopted** **them** completely. **The** combination **of** **the** **religious** instinct **of** **Asia** **with** **the** philosophic **spirit** **of** **Greece** **spread** **across** **the** **world** **in** **the** era after Alexander’s **death**, blending **the** **culture** **of** **the** **Middle East** **East** **with** **the** **culture** **of** **Greece**.

count: 231

# Official 07-Passage 03 Agriculture, Iron, and the Bantu Peoples

**There** **is** **evidence** **of** **agriculture** **in** **Africa** prior **to** 3000 B.C. **It** may **have** **developed** independently, **but** **many** **scholars** **believe** **that** **the** **spread** **of** **agriculture** **and** **iron** **throughout** **Africa** **linked** **it** **to** **the** **major** centers **of** **the** **Near** **East** **and** Mediterranean **world**. **The** **drying** **up** **of** **what** **is** **now** **the** Sahara **desert** **had** **pushed** **many** **peoples** **to** **the** **south** **into** sub-Saharan **Africa**. **These** **peoples** **settled** **at** **first** **in** scattered **hunting**-**and**-**gathering** **bands**, **although** **in** **some** **places** **near** **lakes** **and** **rivers**, **people** **who** **fished**, **with** **a** **more** **secure** **food** **supply**, **lived** **in** larger **population** concentrations. **Agriculture** **seems** **to** **have** **reached** **these** **people** **from** **the** **Near** **East**, **since** **the** **first** domesticated **crops** **were** millets **and** sorghums **whose** **origins** **are** **not** **African** **but** **West** **Asian**. **Once** **the** **idea** **of** **planting** diffused, Africans **began** **to** **develop** **their** **own** **crops**, **such** **as** **certain** **varieties** **of** **rice**, **and** **they** demonstrated **a** **continued** receptiveness **to** **new** **imports**. **The** proposed **areas** **of** **the** domestication **of** **African** **crops** **lie** **in** **a** **band** **that** extends **from** Ethiopia **across** **southern** Sudan **to** **West** **Africa**. Subsequently, **other** **crops**, **such** **as** **bananas**, **were** **introduced** **from** **Southeast** **Asia**.

Livestock **also** **came** **from** **outside** **Africa**. **Cattle** **were** **introduced** **from** **Asia**, **as** **probably** **were** domestic **sheep** **and** **goats**. **Horses** **were** apparently **introduced** **by** **the** Hyksos invaders **of** **Egypt** (1780–1560 B.C.) **and** **then** **spread** **across** **the** Sudan **to** **West** **Africa**. **Rock** **paintings** **in** **the** Sahara indicate **that** **horses** **and** chariots **were** **used** **to** traverse **the** **desert** **and** **that** **by** 300–200 B.C., **there** **were** **trade** routes **across** **the** Sahara. **Horses** **were** **adopted** **by** **peoples** **of** **the** **West** **African** savannah, **and** **later** **their** **powerful** cavalry **forces** **allowed** **them** **to** **carve** **out** **large** **empires**. Finally, **the** **camel** **was** **introduced** **around** **the** **first** **century** **A**.D. **This** **was** an **important** innovation, **because** **the** **camel**’s **ability** **to** thrive **in** harsh **desert** **conditions** **and** **to** **carry** **large** **loads** cheaply **made** **it** an effective **and** efficient **means** **of** transportation. **The** **camel** **transformed** **the** **desert** **from** **a** **barrier** **into** **a** **still** **difficult**, **but** **more** **accessible**, route **of** **trade** **and** **communication**.

**Iron** **came** **from** **West** **Asia**, **although** **its** routes **of** diffusion **were** somewhat **different** **than** **those** **of** **agriculture**. **Most** **of** **Africa** **presents** **a** **curious** **case** **in** **which** **societies** **moved** directly **from** **a** **technology** **of** **stone** **to** **iron** **without** **passing** **through** **the** intermediate **stage** **of** copper **or** bronze metallurgy, **although** **some** **early** copper-**working** sites **have** **been** **found** **in** **West** **Africa**. **Knowledge** **of** **iron** **making** penetrated **into** **the** **forests** **and** savannahs **of** **West** **Africa** **at** roughly **the** **same** **time** **that** **iron** **making** **was** **reaching** **Europe**. **Evidence** **of** **iron** **making** **has** **been** **found** **in** Nigeria, Ghana, **and** Mali.

**This** technological shift **caused** profound **changes** **in** **the** complexity **of** **African** **societies**. **Iron** **represented** **power**. **In** **West** **Africa** **the** blacksmith **who** **made** **tools** **and** weapons **had** an **important** **place** **in** **society**, **often** **with** **special** **religious** **powers** **and** **functions**. **Iron** hoes, **which** **made** **the** **land** **more** productive, **and** **iron** weapons, **which** **made** **the** warrior **more** **powerful**, **had** symbolic **meaning** **in** **a** **number** **of** **West** **African** **societies**. **Those** **who** **knew** **the** **secrets** **of** **making** **iron** **gained** ritual **and** **sometimes** **political** **power**.

**Unlike** **in** **the** Americas, **where** metallurgy **was** **a** **very** **late** **and** **limited** **development**, Africans **had** **iron** **from** **a** relatively **early** **date**, **developing** ingenious furnaces **to** **produce** **the** **high** **heat** **needed** **for** **production** **and** **to** **control** **the** **amount** **of** **air** **that** **reached** **the** **carbon** **and** **iron** ore **necessary** **for** **making** **iron**. **Much** **of** **Africa** **moved** **right** **into** **the** **Iron** **Age**, **taking** **the** **basic** **technology** **and** **adapting** **it** **to** **local** **conditions** **and** resources.

**The** diffusion **of** **agriculture** **and** **later** **of** **iron** **was** **accompanied** **by** **a** **great** **movement** **of** **people** **who** may **have** **carried** **these** innovations. **These** **people** **probably** originated **in** **eastern** Nigeria. **Their** migration may **have** **been** **set** **in** motion **by** an **increase** **in** **population** **caused** **by** **a** **movement** **of** **peoples** **fleeing** **the** desiccation, **or** **drying** **up**, **of** **the** Sahara. **They** **spoke** **a** **language**, proto-Bantu (“bantu” **means** “**the** **people**”), **which** **is** **the** **parent** **tongue** **of** **a** **large** **number** **of** Bantu **languages** **still** **spoken** **throughout** sub-Saharan **Africa**. **Why** **and** **how** **these** **people** **spread** **out** **into** **central** **and** **southern** **Africa** **remains** **a** mystery, **but** archaeologists **believe** **that** **their** **iron** weapons **allowed** **them** **to** conquer **their** **hunting**-**gathering** opponents, **who** **still** **used** **stone** implements. **Still**, **the** **process** **is** **uncertain**, **and** **peaceful** migration—**or** **simply** **rapid** demographic **growth**—may **have** **also** **caused** **the** Bantu explosion.

count: 230

# Official 19-Passage 01 The Roman Army's Impact on Britain

**In** **the** **wake** **of** **the** Roman **Empire**’s conquest **of** **Britain** **in** **the** **first** **century** **A**.D., **a** **large** **number** **of** **troops** **stayed** **in** **the** **new** **province**, **and** **these** **troops** **had** **a** considerable impact **on** **Britain** **with** **their** **camps**, fortifications, **and** participation **in** **the** **local** economy. **Assessing** **the** impact **of** **the** **army** **on** **the** **civilian** **population** **starts** **from** **the** realization **that** **the** **soldiers** **were** **always** unevenly **distributed** **across** **the** **country**. **Areas** rapidly incorporated **into** **the** **empire** **were** **not** **long** **affected** **by** **the** military. **Where** **the** **army** **remained** **stationed**, **its** presence **was** **much** **more** influential. **The** imposition **of** **a** military **base** involved **the** requisition **of** **native** **lands** **for** **both** **the** fort **and** **the** territory **needed** **to** **feed** **and** **exercise** **the** **soldiers**’ **animals**. **The** imposition **of** military **rule** **also** **robbed** **local** **leaders** **of** opportunities **to** **participate** **in** **local** **government**, **so** **social** **development** **was** stunted **and** **the** **seeds** **of** disaffection **sown**. **This** **then** **meant** **that** **the** military **had** **to** **remain** **to** suppress rebellion **and** organize **government**.

Economic **exchange** **was** **clearly** **very** **important** **as** **the** Roman **army** **brought** **with** **it** **very** substantial **spending** **power**. Locally **a** fort **had** **two** **kinds** **of** impact. **Its** **large** **population** **needed** **food** **and** **other** **supplies**. **Some** **of** **these** **were** **certainly** **brought** **from** **long** **distances**, **but** **demands** **were** inevitably **placed** **on** **the** **local** **area**. **Although** **goods** **could** **be** requisitioned, **they** **were** **usually** **paid** **for**, **and** **this** **probably** stimulated **changes** **in** **the** **local** economy. **When** **not** **campaigning**, **soldiers** **needed** **to** **be** occupied; **otherwise** **they** **represented** **a** potentially **dangerous** source **of** **friction** **and** disloyalty. Hence **a** **writing** **tablet** **dated** 25 **April** **tells** **of** 343 **men** **at** **one** fort engaged **on** **tasks** **like** shoemaking, **building** **a** bathhouse, **operating** kilns, **digging** **clay**, **and** **working** **lead**. **Such** **activities** **had** **a** **major** **effect** **on** **the** **local** **area**, **in** **particular** **with** **the** **construction** **of** infrastructure **such** **as** **roads**, **which** **improved** **access** **to** **remote** **areas**.

**Each** **soldier** **received** **his** **pay**, **but** **in** regions **without** **a** **developed** economy **there** **was** initially **little** **on** **which** **it** **could** **be** **spent**. **The** **pool** **of** excess **cash** rapidly stimulated **a** thriving economy **outside** fort **gates**. **Some** **of** **the** **demand** **for** **the** **services** **and** **goods** **was** **no** **doubt** fulfilled **by** **people** **drawn** **from** **far** afield, **but** **some** **local** **people** **certainly** **became** entwined **in** **this** **new** economy. **There** **was** informal **marriage** **with** **soldiers**, **who** **until** **A**.D. 197 **were** **not** legally entitled **to** wed, **and** **whole** **new** communities **grew** **up** **near** **the** forts. **These** **settlements** **acted** **like** **small** **towns**, **becoming** centers **for** **the** artisan **and** **trading** **populations**.

**The** **army** **also** **provided** **a** **means** **of** **personal** advancement **for** auxiliary **soldiers** recruited **from** **the** **native** **peoples**, **as** **a** **man** **obtained** hereditary Roman citizenship **on** retirement after **service** **in** an auxiliary regiment. **Such** **units** recruited **on** an **ad** hoc (**as** **needed**) **basis** **from** **the** **area** **in** **which** **they** **were** **stationed**, **and** **there** **was** evidently **large**-scale recruitment **within** **Britain**. **The** **total** **numbers** **were** **at** **least** 12,500 **men** **up** **to** **the** reign **of** **the** **emperor** Hadrian (**A**.D. 117--138), **with** **a** peak **around** **A**.D. 80. **Although** **a** **small** proportion **of** **the** **total** **population**, **this** **perhaps** **had** **a** massive **local** impact **when** **a** **large** proportion **of** **the** **young** **men** **were** **removed** **from** an **area**. Newly **raised** regiments **were** normally transferred **to** **another** **province** **from** whence **it** **was** unlikely **that** individual recruits **would** **ever** **return**. **Most** **units** **raised** **in** **Britain** **went** elsewhere **on** **the** **European** **continent**, **although** **one** **is** **recorded** **in** Morocco. **The** reverse **process** **brought** **young** **men** **to** **Britain**, **where** **many** **continued** **to** **live** after **their** 20 **to** 25 **years** **of** **service**, **and** **this** **added** **to** **the** cosmopolitan Roman **character** **of** **the** **frontier** **population**. **By** **the** **later** Roman **period**, **frontier** garrisons (**groups** **of** **soldiers**) **were** **only** rarely transferred, **service** **in** **units** **became** effectively hereditary, **and** forts **were** **no** longer populated **or** maintained **at** **full** **strength**.

**This** **process** **of** **settling** **in** **as** **a** community **over** **several** **generations**, **combined** **with** **local** recruitment, presumably **accounts** **for** **the** **apparent** stability **of** **the British** **northern** **frontier** **in** **the** **later** Roman **period**. **It** **also** **explains** **why** **some** **of** **the** forts **continued** **in** **occupation** **long** after Rome ceased **to** **have** **any** formal **authority** **in** **Britain**, **at** **the** **beginning** **of** **the** **fifth** **century** **A**.D. **The** **circumstances** **that** **had** **allowed** **natives** **to** **become** Romanized **also** **led** **the** **self**-sustaining military community **of** **the** **frontier** **area** **to** **become** effectively **British**.

count: 230

# Official 01-Passage 02 The Origins of Theater

**In** **seeking** **to** **describe** **the** **origins** **of** theater, **one** must **rely** primarily **on** speculation, **since** **there** **is** **little** **concrete** **evidence** **on** **which** **to** **draw**. **The** **most** widely **accepted** **theory**, **championed** **by** anthropologists **in** **the** **late** nineteenth **and** **early** **twentieth** **centuries**, envisions theater **as** emerging **out** **of** myth **and** ritual. **The** **process** perceived **by** **these** anthropologists may **be** summarized briefly. **During** **the** **early** **stages** **of** **its** **development**, **a** **society** **becomes** **aware** **of** **forces** **that** **appear** **to** **influence** **or** **control** **its** **food** **supply** **and** **well**-**being**. **Having** **little** **understanding** **of** **natural** **causes**, **it** attributes **both** desirable **and** undesirable occurrences **to** supernatural **or** magical **forces**, **and** **it** **searches** **for** **means** **to** **win** **the** favor **of** **these** **forces**. Perceiving an **apparent** **connection** **between** **certain** **actions** **performed** **by** **the** **group** **and** **the** **result** **it** **desires**, **the** **group** **repeats**, refines, **and** formalizes **those** **actions** **into** **fixed** **ceremonies**, **or** rituals.

**Stories** (myths) may **then** **grow** **up** **around** **a** ritual. Frequently **the** myths **include** **representatives** **of** **those** supernatural **forces** **that** **the** rites **celebrate** **or** **hope** **to** **influence**. **Performers** may **wear** costumes **and** **masks** **to** **represent** **the** mythical **characters** **or** supernatural **forces** **in** **the** rituals **or** **in** **accompanying** **celebrations**. **As** **a** **people** **becomes** **more** sophisticated, **its** conceptions **of** supernatural **forces** **and** causal **relationships** may **change**. **As** **a** **result**, **it** may **abandon** **or** modify **some** rites. **But** **the** myths **that** **have** **grown** **up** **around** **the** rites may **continue** **as** **part** **of** **the** **group**’s **oral** **tradition** **and** may **even** **come** **to** **be** **acted** **out** **under** **conditions** **divorced** **from** **these** rites. **When** **this** **occurs**, **the** **first** **step** **has** **been** **taken** **toward** theater **as** an **autonomous** **activity**, **and** thereafter **entertainment** **and** aesthetic **values** may **gradually** **replace** **the** **former** mystical **and** socially efficacious **concerns**.

**Although** **origin** **in** ritual **has** **long** **been** **the** **most** **popular**, **it** **is** **by** **no** **means** **the** **only** **theory** **about** **how** **the** theater **came** **into** **being**. Storytelling **has** **been** proposed **as** **one** **alternative**. **Under** **this** **theory**, **relating** **and** **listening** **to** **stories** **are** **seen** **as** **fundamental** **human** **pleasures**. **Thus**, **the** recalling **of** an **event** (**a** **hunt**, **battle**, **or** **other** feat) **is** elaborated **through** **the** narrator’s pantomime **and** impersonation **and** **eventually** **through** **each** **role** **being** **assumed** **by** **a** **different** **person**.

**A** closely **related** **theory** **sees** theater **as** evolving **out** **of** **dances** **that** **are** primarily pantomimic, rhythmical **or** gymnastic, **or** **from** imitations **of** **animal** **noises** **and** **sounds**. Admiration **for** **the** **performer**’s **skill**, virtuosity, **and** grace **are** **seen** **as** **motivation** **for** elaborating **the** **activities** **into** fully realized theatrical **performances**.

**In** **addition** **to** **exploring** **the** **possible** antecedents **of** theater, **scholars** **have** **also** theorized **about** **the** motives **that** **led** **people** **to** **develop** theater. **Why** **did** theater **develop**, **and** **why** **was** **it** **valued** after **it** ceased **to** fulfill **the** **function** **of** ritual? **Most** **answers** **fall** **back** **on** **the** **theories** **about** **the** **human** **mind** **and** **basic** **human** **needs**. **One**, **set** forth **by** Aristotle **in** **the** **fourth** **century** B.C., **sees** **humans** **as** naturally imitative—**as** **taking** **pleasure** **in** imitating **persons**, **things**, **and** **actions** **and** **in** **seeing** **such** imitations. **Another**, **advanced** **in** **the** **twentieth** **century**, **suggests** **that** **humans** **have** **a** **gift** **for** **fantasy**, **through** **which** **they** **seek** **to** reshape **reality** **into** **more** **satisfying** **forms** **than** **those** encountered **in** **daily** **life**. **Thus**, **fantasy** **or** **fiction** (**of** **which** drama **is** **one** **form**) **permits** **people** **to** objectify **their** **anxieties** **and** **fears**, confront **them**, **and** fulfill **their** **hopes** **in** **fiction** **if** **not** **fact**. **The** theater, **then**, **is** **one** **tool** whereby **people** define **and** **world** **or** **escape** **from** **unpleasant** **realities**.

**But** **neither** **the** **human** imitative instinct **nor** **a** penchant **for** **fantasy** **by** **itself** **leads** **to** an **autonomous** theater. **Therefore**, additional **explanations** **are** **needed**. **One** **necessary** **condition** **seems** **to** **be** **a** somewhat detached **view** **of** **human** **problems**. **For** **example**, **one** **sign** **of** **this** **condition** **is** **the** **appearance** **of** **the** comic vision, **since** **comedy** **requires** sufficient detachment **to** **view** **some** deviations **from** **social** norms **as** **ridiculous** **rather** **than** **as** **serious** threats **to** **the** **welfare** **of** **the** **entire** **group**. **Another** **condition** **that** **contributes** **to** **the** **development** **of** **autonomous** theater **is** **the** emergence **of** **the** aesthetic **sense**. **For** **example**, **some** **early** **societies** ceased **to** **consider** **certain** rites essential **to** **their** **well**-**being** **and** **abandoned** **them**; nevertheless, **they** retained **as** **parts** **of** **their** **oral** **tradition** **the** myths **that** **had** **grown** **up** **around** **the** rites **and** **admired** **them** **for** **their** artistic **qualities** **rather** **than** **for** **their** **religious** usefulness.

count: 230

# Official 06-Passage 03 Infantile Amnesia

**What** **do** **you** **remember** **about** **your** **life** **before** **you** **were** **three**? **Few** **people** **can** **remember** **anything** **that** **happened** **to** **them** **in** **their** **early** **years**. **Adults**’ **memories** **of** **the** **next** **few** **years** **also** **tend** **to** **be** scanty. **Most** **people** **remember** **only** **a** **few** **events**—**usually** **ones** **that** **were** meaningful **and** distinctive, **such** **as** **being** hospitalized **or** **a** sibling’s **birth**.

**How** **might** **this** inability **to** recall **early** **experiences** **be** **explained**? **The** sheer **passage** **of** **time** **does** **not** **account** **for** **it**; **adults** **have** **excellent** recognition **of** **pictures** **of** **people** **who** **attended** **high** **school** **with** **them** 35 **years** earlier. **Another** seemingly plausible **explanation**—**that** infants **do** **not** **form** enduring **memories** **at** **this** **point** **in** **development**—**also** **is** **incorrect**. **Children** **two** **and** **a** **half** **to** **three** **years** **old** **remember** **experiences** **that** **occurred** **in** **their** **first** **year**, **and** **eleven** **month** **olds** **remember** **some** **events** **a** **year** **later**. **Nor** **does** **the** hypothesis **that** infantile amnesia **reflects** repression— **or** **holding** **back**— **of** sexually **charged** episodes **explain** **the** **phenomenon**. **While** **such** repression may **occur**, **people** cannot **remember** **ordinary** **events** **from** **the** infant **and** toddler **periods**, **either**.

**Three** **other** **explanations** **seem** **more** **promising**. **One** involves physiological **changes** **relevant** **to** **memory**. Maturation **of** **the** frontal lobes **of** **the** **brain** **continues** **throughout** **early** **childhood**, **and** **this** **part** **of** **the** **brain** may **be** critical **for** **remembering** **particular** episodes **in** **ways** **that** **can** **be** retrieved **later**. Demonstrations **of** infants’ **and** toddlers’ **long**-**term** **memory** **have** involved **their** **repeating** **motor** **activities** **that** **they** **had** **seen** **or** **done** earlier, **such** **as** **reaching** **in** **the** **dark** **for** **objects**, **putting** **a** **bottle** **in** **a** **doll**’s **mouth**, **or** **pulling** **apart** **two** **pieces** **of** **a** **toy**. **The** **brain**’s **level** **of** physiological maturation may **support** **these** **types** **of** **memories**, **but** **not** **ones** **requiring** **explicit** verbal **descriptions**.

**A** **second** **explanation** involves **the** **influence** **of** **the** **social** **world** **on** **children**’s **language** **use**. **Hearing** **and** **telling** **stories** **about** **events** may **help** **children** **store** **information** **in** **ways** **that** **will** endure **into** **later** **childhood** **and** adulthood. **Through** **hearing** **stories** **with** **a** **clear** **beginning**, **middle**, **and** **ending**, **children** may **learn** **to** extract **the** gist **of** **events** **in** **ways** **that** **they** **will** **be** **able** **to** **describe** **many** **years** **later**. **Consistent** **with** **this** **view**, **parents** **and** **children** increasingly engage **in** **discussions** **of** **past** **events** **when** **children** **are** **about** **three** **years** **old**. **However**, **hearing** **such** **stories** **is** **not** sufficient **for** younger **children** **to** **form** enduring **memories**. **Telling** **such** **stories** **to** **two** **year** **olds** **does** **not** **seem** **to** **produce** **long**-**lasting** verbalizable **memories**.

**A** **third** **likely** **explanation** **for** infantile amnesia involves incompatibilities **between** **the** **ways** **in** **which** infants encode[1]**information** **and** **the** **ways** **in** **which** older **children** **and** **adults** retrieve **it**. **Whether** **people** **can** **remember** an **event** **depends** critically **on** **the** **fit** **between** **the** **way** **in** **which** **they** earlier encoded **the** **information** **and** **the** **way** **in** **which** **they** **later** **attempt** **to** retrieve **it**. **The** **better** **able** **the** **person** **is** **to** reconstruct **the** perspective **from** **which** **the** **material** **was** encoded, **the** **more** **likely** **that** recall **will** **be** **successful**.

**This** **view** **is** **supported** **by** **a** **variety** **of** factors **that** **can** **create** mismatches **between** **very** **young** **children**’s encoding **and** older **children**’s **and** **adults**’ retrieval **efforts**. **The** **world** **looks** **very** **different** **to** **a** **person** **whose** **head** **is** **only** **two** **or** **three** **feet** **above** **the** **ground** **than** **to** **one** **whose** **head** **is** **five** **or** **six** **feet** **above** **it**. Older **children** **and** **adults** **often** **try** **to** retrieve **the** **names** **of** **things** **they** **saw**, **but** infants **would** **not** **have** encoded **the** **information** verbally. **General** **knowledge** **of** **categories** **of** **events** **such** **as** **a** **birthday** **party** **or** **a** **visit** **to** **the** **doctor**’s **office** **helps** older individuals encode **their** **experiences**, **but** **again**, infants **and** toddlers **are** unlikely **to** encode **many** **experiences** **within** **such** **knowledge** structures.

**These** **three** **explanations** **of** infantile amnesia **are** **not** mutually exclusive; **indeed**, **they** **support** **each** **other**. Physiological immaturity may **be** **part** **of** **why** infants **and** toddlers **do** **not** **form** **extremely** enduring **memories**, **even** **when** **they** **hear** **stories** **that** **promote** **such** **remembering** **in** preschoolers. **Hearing** **the** **stories** may **lead** preschoolers **to** encode **aspects** **of** **events** **that** **allow** **them** **to** **form** **memories** **they** **can** **access** **as** **adults**. Conversely, **improved** encoding **of** **what** **they** **hear** may **help** **them** **better** **understand** **and** **remember** **stories** **and** **thus** **make** **the** **stories** **more** **useful** **for** **remembering** **future** **events**. **Thus**, **all** **three** **explanations**—physiological maturation, **hearing** **and** **producing** **stories** **about** **past** **events**, **and** **improved** encoding **of** **key** **aspects** **of** **events**—**seem** **likely** **to** **be** involved **in** **overcoming** infantile amnesia.

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[1] encode: transfer **information** **from** **one** **system** **of** **communication** **into** **another**

count: 229

# Official 16-Passage 01 Trade and the Ancient Middle East

**Trade** **was** **the** mainstay **of** **the** **urban** economy **in** **the** **Middle East** **East**, **as** caravans **negotiated** **the** **surrounding** **desert**, **restricted** **only** **by** **access** **to** **water** **and** **by** **mountain** **ranges**. **This** **has** **been** **so** **since** **ancient** **times**, **partly** **due** **to** **the** geology **of** **the** **area**, **which** **is** mostly limestone **and** sandstone, **with** **few** **deposits** **of** metallic ore **and** **other** **useful** **materials**. **Ancient** **demands** **for** obsidian (**a** **black** volcanic **rock** **useful** **for** **making** **mirrors** **and** **tools**) **led** **to** **trade** **with** Armenia **to** **the** **north**, **while** jade **for** **cutting** **tools** **was** **brought** **from** Turkistan, **and** **the** **precious** **stone** lapis lazuli **was** **imported** **from** Afghanistan. **One** **can** trace **such** expeditions **back** **to** **ancient** Sumeria, **the** earliest **known** **Middle** **Eastern** **civilization**. **Records** **show** **merchant** caravans **and** **trading** **posts** **set** **up** **by** **the** Sumerians **in** **the** **surrounding** **mountains** **and** **deserts** **of** Persia **and** Arabia, **where** **they** **traded** **grain** **for** **raw** **materials**, **such** **as** timber **and** **stones**, **as** **well** **as** **for** **metals** **and** gems.

Reliance **on** **trade** **had** **several** **important** **consequences**. **Production** **was** generally **in** **the** **hands** **of** **skilled** individual artisans **doing** piecework **under** **the** tutelage **of** **a** **master** **who** **was** **also** **the** **shop** **owner**. **In** **these** **shops** **differences** **of** **rank** **were** blurred **as** artisans **and** **masters** labored **side** **by** **side** **in** **the** **same** **modest** establishment, **were** **usually** **members** **of** **the** **same** guild **and** **religious** sect, **lived** **in** **the** **same** neighborhoods, **and** **often** **had** **assumed** (**or** **real**) kinship **relationships**. **The** **worker** **was** **bound** **to** **the** **master** **by** **a** mutual contract **that** **either** **one** **could** repudiate, **and** **the** **relationship** **was** conceptualized **as** **one** **of** partnership.

**This** mode **of** craft **production** favored **the** **growth** **of** **self**-**governing** **and** ideologically egalitarian craft guilds **everywhere** **in** **the** **Middle** **Eastern** **city**. **These** **were** essentially professional **associations** **that** **provided** **for** **the** mutual **aid** **and** **protection** **of** **their** **members**, **and** **allowed** **for** **the** maintenance **of** professional **standards**. **The** **growth** **of** **independent** guilds **was** furthered **by** **the** **fact** **that** **surplus** **was** **not** **a** **result** **of** domestic craft **production** **but** **resulted** primarily **from** **international** **trading**; **the** **government** **left** **working** **people** **to** **govern** **themselves**, **much** **as** shepherds **of** tribal confederacies **were** **left** **alone** **by** **their** **leaders**. **In** **the** multiplicity **of** **small**-scale **local** egalitarian **or** quasi-egalitarian **organizations** **for** fellowship, worship, **and** **production** **that** flourished **in** **this** laissez-faire **environment**, individuals **could** interact **with** **one** **another** **within** **a** community **of** **harmony** **and** ideological **equality**, **following** **their** **own** popularly **elected** **leaders** **and** **governing** **themselves** **by** **shared** **consensus** **while** minimizing **distinctions** **of** **wealth** **and** **power**.

**The** mercantile economy **was** **also** characterized **by** **a** peculiar **moral** stance **that** **is** **typical** **of** **people** **who** **live** **by** **trade**—an **attitude** **that** **is** individualistic, **calculating**, **risk** **taking**, **and** adaptive **to** **circumstances**. **As** **among** tribespeople, **personal** **relationships** **and** **a** **careful** **weighing** **of** **character** **have** **always** **been** crucial **in** **a** mercantile economy **with** **little** **regulation**, **where** **one**’s **word** **is** **one**’s **bond** **and** **where** informal **ties** **of** **trust** cement **together** an **international** **trade** **network**. **Nor** **have** **merchants** **and** artisans **ever** **had** **much** tolerance **for** aristocratic **professions** **of** **moral** superiority, favoring **instead** an egalitarian ethic **of** **the** **open** **market**, **where** **steady** **hard** **work**, **the** loyalty **of** **one**’s **fellows**, **and** entrepreneurial **skill** **make** **all** **the** **difference**. **And**, **like** **the** pastoralists, **Middle** **Eastern** **merchants** **and** artisans **unhappy** **with** **their** **environment** **could** **simply** **pack** **up** **and** **leave** **for** greener pastures—an **act** **of** **self**-assertion wholly **impossible** **in** **most** **other** **civilizations** **throughout** **history**.

Dependence **on** **long**-**distance** **trade** **also** **meant** **that** **the** **great** **empires** **of** **the** **Middle East** **East** **were** **built** **both** literally **and** figuratively **on** shifting **sand**. **The** **central** **state**, **though** **often** **very** **rich** **and** **very** populous, **was** intrinsically **fragile**, **since** **the** **development** **of** **new** **international** **trade** routes **could** undermine **the** monetary **base** **and** erode **state** **power**, **as** **occurred** **when** **European** seafarers circumvented **Middle** **Eastern** **merchants** after Vasco da Gama’s **voyage** **around** **Africa** **in** **the** **late** fifteenth-**century** **opened** **up** **a** **southern** route. **The** **ecology** **of** **the** region **also** **permitted** **armed** predators **to** prowl **the** **surrounding** barrens, **which** **were** **almost** **impossible** **for** **a** **state** **to** **control**. Peripheral **peoples** **therefore** **had** **a** **great** **advantage** **in** **their** dealings **with** **the** center, **making** **government** **authority** insecure **and** **anxious**.

count: 229

# Official 22-Passage 02 The Birth of Photography

Perceptions **of** **the** visible **world** **were** greatly altered **by** **the** **invention** **of** photography **in** **the** **middle** **of** **the** nineteenth **century**. **In** **particular**, **and** **quite** logically, **the** **art** **of** **painting** **was** **forever** **changed**, **though** **not** **always** **in** **the** **ways** **one** **might** **have** **expected**. **The** realistic **and** naturalistic **painters** **of** **the** mid- **and** **late**-nineteenth **century** **were** **all** intently **aware** **of** photography —**as** **a** **thing** **to** **use**, **to** **learn** **from**, **and** **react** **to**.

**Unlike** **most** **major** **inventions**, photography **had** **been** **long** **and** impatiently awaited. **The** images **produced** **by** **the** **camera** obscura, **a** boxlike device **that** **used** **a** pinhole **or** lens **to** **throw** an image **onto** **a** **ground**-**glass** **screen** **or** **a** **piece** **of** **white** **paper**, **were** **already** **familiar**—**the** device **had** **been** **much** **employed** **by** topographical **artists** **like** **the** **Italian** **painter** Canaletto **in** **his** detailed **views** **of** **the** **city** **of** Venice. **What** **was** **lacking** **was** **a** **way** **of** **giving** **such** images **permanent** **form**. **This** **was** finally **achieved** **by** Louis Daguerre (1787-1851), **who** **perfected** **a** **way** **of** **fixing** **them** **on** **a** **silvered** copper **plate**. **His** **discovery**, **the** “daguerreotype,” **was** **announced** **in** 1839.

**A** **second** **and** **very** **different** **process** **was** **patented** **by** **the British** **inventor** William Henry Talbot (1800-1877) **in** 1841. Talbot’s “calotype” **was** **the** **first** negative-**to**-positive **process** **and** **the** **direct** **ancestor** **of** **the** **modern** **photograph**. **The** calotype **was** revolutionary **in** **its** **use** **of** chemically **treated** **paper** **in** **which** **areas** **hit** **by** **light** **became** **dark** **in** tone, **producing** **a** negative image. **This** “negative,” **as** Talbot **called** **it**, **could** **then** **be** **used** **to** **print** multiple positive images **on** **another** **piece** **of** **treated** **paper**.

**The** **two** **processes** **produced** **very** **different** **results**. **The** daguerreotype **was** **a** **unique** image **that** reproduced **what** **was** **in** **front** **of** **the** **camera** lens **in** **minute**, unselective detail **and** **could** **not** **be** duplicated. **The** calotype **could** **be** **made** **in** series, **and** **was** **thus** **the** equivalent **of** an etching **or** an engraving. **Its** **general** **effect** **was** **soft** **edged** **and** tonal.

**One** **of** **the** **things** **that** **most** **impressed** **the** original **audience** **for** photography **was** **the** **idea** **of** authenticity. **Nature** **now** **seemed** **able** **to** **speak** **for** **itself**, **with** **a** **minimum** **of** interference. **The** **title** Talbot **chose** **for** **his** **book**, **The** **Pencil** **of** **Nature** (**the** **first** **part** **of** **which** **was** **published** **in** 1844), **reflected** **this** **feeling**.**Artists** **were** fascinated **by** photography b ecause **it** **offered** **a** **way** **of** **examining** **the** **world** **in** **much** greater detail. **They** **were** **also** **afraid** **of** **it**, **because** **it** **seemed** **likely** **to** **make** **their** **own** **efforts** unnecessary.

Photography **did** **indeed** **make** **certain** **kinds** **of** **painting** obsolete—**the** daguerreotype virtually **did** **away** **with** **the** portrait miniature. **It** **also** **made** **the** **whole** **business** **of** **making** **and** **owning** images democratic. Portraiture, **once** **a** luxury **for** **the** **privileged** **few**, **was** suddenly **well** **within** **the** **reach** **of** **many** **more** **people**.

**In** **the** **long** **term**, photography’s impact **on** **the** **visual** **arts** **was** **far** **from** **simple**. **Because** **the** **medium** **was** **so** prolific, **in** **the** **sense** **that** **it** **was** **possible** **to** **produce** **a** multitude **of** images **very** cheaply, **it** **was** **soon** **treated** **as** **the** **poor** **relation** **of** **fine** **art**, **rather** **than** **its** destined successor. **Even** **those** **artists** **who** **were** **most** dependent **on** photography **became** reluctant **to** **admit** **that** **they** **made** **use** **of** **it**, **in** **case** **this** **compromised** **their** professional **standing**.

**The** **rapid** **technical** **development** **of** photography—**the** **introduction** **of** lighter **and** simpler **equipment**, andof **new** emulsions **that** **coated** photographic **plates**, **film**, **and** **paper** **and** enabled images **to** **be** **made** **at** **much** faster **speeds**—**had** **some** unanticipated **consequences**. **Scientific** **experiments** **made** **by** **photographers** **such** **as** Eadweard Muybridge (1830-1904) **and** Etienne-Jules Marey (1830-1904) demonstrated **that** **the** **movements** **of** **both** **humans** **and** **animals** **differed** widely **from** **the** **way** **they** **had** **been** traditionally **represented** **in** **art**. **Artists**, **often** reluctantly, **were** **forced** **to** **accept** **the** **evidence** **provided** **by** **the** **camera**. **The** **new** candid photography—unposed **pictures** **that** **were** **made** **when** **the** **subjects** **were** unaware **that** **their** **pictures** **were** **being** **taken**—**confirmed** **these** **scientific** **results**, **and** **at** **the** **same** **time**, **thanks** **to** **the** radical **cropping** (trimming) **of** images **that** **the** **camera** **often** imposed, **suggested** **new** compositional **formats**. **The** accidental **effects** **obtained** **by** candid **photographers** **were** **soon** **being** **copied** **by** **artists** **such** **as** **the** **French** **painter** Degas.

count: 229

# Official 17-Passage 01 Europe's Early Sea Trade with Asia

**In** **the** fourteenth **century**, **a** **number** **of** **political** **developments** **cut** **Europe**’s overland **trade** routes **to** **southern** **and** **eastern** **Asia**, **with** **which** **Europe** **had** **had** **important** **and** highly profitable commercial **ties** **since** **the** **twelfth** **century**. **This** **development**, **coming** **as** **it** **did** **when** **the** **bottom** **had** **fallen** **out** **of** **the** **European** economy, **provided** an impetus **to** **a** **long**-**held** **desire** **to** **secure** **direct** **relations** **with** **the** **East** **by** establishing **a** **sea** **trade**. Widely **reported**, **if** somewhat distrusted, **accounts** **by** **figures** **like** **the** **famous** **traveler** **from** Venice, Marco Polo, **of** **the** **willingness** **of** **people** **in** **China** **to** **trade** **with** Europeans **and** **of** **the** immensity **of** **the** **wealth** **to** **be** **gained** **by** **such** contact **made** **the** **idea** irresistible. **Possibilities** **for** **trade** **seemed** **promising**, **but** **no** **hope** **existed** **for** maintaining **the** **traditional** routes **over** **land**. **A** **new** **way** **had** **to** **be** **found**.

**The** **chief** **problem** **was** technological: **How** **were** **the** Europeans **to** **reach** **the** **East**? **Europe**’s maritime **tradition** **had** **developed** **in** **the** context **of** **easily** navigable **seas**—**the** Mediterranean, **the** Baltic, **and**, **to** **a** lesser extent, **the** **North** **Sea** **between** **England** **and** **the** **Continent**—**not** **of** **vast** **oceans**. **New** **types** **of** **ships** **were** **needed**, **new** **methods** **of** **finding** **one**’s **way**, **new** **techniques** **for** **financing** **so** **vast** **a** scheme. **The** sheer scale **of** **the** investment **it** **took** **to** **begin** commercial expansion **at** **sea** **reflects** **the** immensity **of** **the** **profits** **that** **such** **East**-**West** **trade** **could** **create**. Spices **were** **the** **most** **sought**-after commodities. Spices **not** **only** dramatically **improved** **the** **taste** **of** **the** **European** **diet** **but** **also** **were** **used** **to** manufacture **perfumes** **and** **certain** **medicines**. **But** **even** **high**-**priced** commodities **like** spices **had** **to** **be** **transported** **in** **large** bulk **in** **order** **to** justify **the** **expense** **and** **trouble** **of** **sailing** **around** **the** **African** **continent** **all** **the** **way** **to** **India** **and** **China**.

**The** principal seagoing **ship** **used** **throughout** **the** **Middle** **Ages** **was** **the** galley, **a** **long**, **low** **ship** **fitted** **with** **sails** **but** **driven** primarily **by** oars. **The** largest galleys **had** **as** **many** **as** 50 oarsmen. **Since** **they** **had** relatively **shallow** hulls, **they** **were** unstable **when** **driven** **by** **sail** **or** **when** **on** **rough** **water**; hence **they** **were** unsuitable **for** **the** **voyage** **to** **the** **East**. **Even** **if** **they** **hugged** **the** **African** coastline, **they** **had** **little** **chance** **of** **surviving** **a** **crossing** **of** **the** **Indian** **Ocean**. **Shortly** after 1400, shipbuilders **began** **developing** **a** **new** **type** **of** vessel **properly** **designed** **to** **operate** **in** **rough**, **open** **water**: **the** caravel. **It** **had** **a** wider **and** deeper hull **than** **the** galley **and** hence **could** **carry** **more** cargo; **increased** stability **made** **it** **possible** **to** **add** multiple masts **and** **sails**. **In** **the** largest caravels, **two** **main** masts **held** **large** **square** **sails** **that** **provided** **the** bulk **of** **the** thrust **driving** **the** **ship** **forward**, **while** **a** smaller **forward** mast **held** **a** triangular-**shaped** **sail**, **called** **a** lateen **sail**, **which** **could** **be** **moved** **into** **a** **variety** **of** **positions** **to** maneuver **the** **ship**.

**The** astrolabe **had** **long** **been** **the** **primary** **instrument** **for** navigation, **having** **been** **introduced** **in** **the** eleventh **century**. **It** **operated** **by** **measuring** **the** **height** **of** **the** **Sun** **and** **the** **fixed** **stars**; **by** **calculating** **the** **angles** **created** **by** **these** **points**, **it** **determined** **the** **degree** **of** latitude **at** **which** **one** **stood**. (**The** **problem** **of** **determining** longitude, **though**, **was** **not** solved **until** **the** eighteenth **century**.) **By** **the** **early** thirteenth **century**, **Western** Europeans **had** **also** **developed** **and** **put** **into** **use** **the** magnetic **compass**, **which** **helped** **when** **clouds** obliterated **both** **the** **Sun** **and** **the** **stars**. **Also** **beginning** **in** **the** thirteenth **century**, **there** **were** **new** **maps** refined **by** **precise** calculations **and** **the** **reports** **of** **sailors** **that** **made** **it** **possible** **to** trace **one**’s **path** **with** **reasonable** **accuracy**. **Certain** institutional **and** **practical** norms **had** **become** established **as** **well**. **A** maritime code **known** **as** **the** Consulate **of** **the** **Sea**, **which** originated **in** **the** **western** Mediterranean region **in** **the** fourteenth **century**, **won** acceptance **by** **a** **majority** **of** **sea** goers **as** **the** normative code **for** maritime **conduct**; **it** defined **such** **matters** **as** **the** **authority** **of** **a** **ship**’s **officers**, protocols **of** **command**, **pay** structures, **the** **rights** **of** **sailors**, **and** **the** **rules** **of** engagement **when** **ships** **met** **one** **another** **on** **the** **sea**-lanes. **Thus** **by** **about** 1400 **the** **key** elements **were** **in** **place** **to** enable **Europe** **to** **begin** **its** seaward **adventure**.

count: 229

# Official 20-Passage 02 Early Settlements in the Southwest Asia

**The** **universal** global **warming** **at** **the** **end** **of** **the** **Ice** **Age** **had** dramatic **effects** **on** temperate regions **of** **Asia**, **Europe**, **and** **North** **America**. **Ice** **sheets** retreated **and** **sea** **levels** **rose**. **The** climatic **changes** **in** southwestern **Asia** **were** **more** subtle, **in** **that** **they** involved shifts **in** **mountain** **snow** **lines**, **rainfall** **patterns**, **and** vegetation **cover**. **However**, **these** **same** **cycles** **of** **change** **had** momentous impacts **on** **the** sparse **human** **populations** **of** **the** region. **At** **the** **end** **of** **the** **Ice** **Age**, **no** **more** **than** **a** **few** **thousand** foragers **lived** **along** **the** **eastern** Mediterranean **coast**, **in** **the** Jordan **and** Euphrates **valleys**. **Within** 2,000 **years**, **the** **human** **population** **of** **the** region **numbered** **in** **the** **tens** **of** **thousands**, **all** **as** **a** **result** **of** **village** **life** **and** **farming**. **Thanks** **to** **new** environmental **and** archaeological **discoveries**, **we** **now** **know** **something** **about** **this** remarkable **change** **in** **local** **life**.

Pollen samples **from** freshwater **lakes** **in** Syria **and** elsewhere **tell** us **forest** **cover** **expanded** rapidly **at** **the** **end** **of** **the** **Ice** **Age**, **for** **the** southwestern **Asian** **climate** **was** **still** cooler **and** considerably wetter **than** **today**. **Many** **areas** **were** richer **in** **animal** **and** **plant** species **than** **they** **are** **now**, **making** **them** highly favorable **for** **human** **occupation**. **About** 9000 B.C., **most** **human** **settlements** **lay** **in** **the** **area** **along** **the** Mediterranean **coast** **and** **in** **the** Zagros **Mountains** **of** Iran **and** **their** foothills. **Some** **local** **areas**, **like** **the** Jordan **River** **valley**, **the** **middle** Euphrates **valley**, **and** **some** Zagros **valleys**, **were** **more** densely populated **than** elsewhere. **Here** **more** sedentary **and** **more** **complex** **societies** flourished. **These** **people** **exploited** **the** landscape intensively, foraging **on** **hill** slopes **for** **wild** cereal **grasses** **and** **nuts**, **while** **hunting** gazellea **small**, swiftly **running** **desert** **animal** **and** **other** **game** **on** grassy lowlands **and** **in** **river** **valleys**. **Their** **settlements** **contain** exotic **objects** **such** **as** **seashells**, **stone** **bowls**, **and** artifacts **made** **of** obsidian (volcanic **glass**), **all** **traded** **from** afar. **This** considerable volume **of** intercommunity **exchange** **brought** **a** **degree** **of** **social** complexity **in** **its** **wake**.

**Thanks** **to** **extremely** **fine**-**grained** excavation **and** extensive **use** **of** flotation **methods** (**through** **which** **seeds** **are** **recovered** **from** **soil** samples), **we** **know** **a** **great** **deal** **about** **the** foraging **practices** **of** **the** inhabitants **of** Abu Hureyra **in** Syria’s Euphrates **valley**. Abu Hureyra **was** **founded** **about** 9500 B.C. **a** **small** **village** **settlement** **of** cramped pit dwellings (**houses** **dug** partially **in** **the** **soil**) **with** reed **roofs** **supported** **by** **wooden** uprights. **For** **the** **next** 1,500 **years**, **its** inhabitants **enjoyed** **a** somewhat warmer **and** damper **climate** **than** **today**, **living** **in** **a** **well**-**wooded** steppe **area** **where** **wild** cereal **grasses** **were** **abundant**. **They** subsisted **off** **spring** migrations **of** Persian gazelles **from** **the** **south**. **With** **such** **a** favorable location, **about** 300 **to** 400 **people** **lived** **in** **a** sizable, **permanent** **settlement**. **They** **were** **no** longer **a** series **of** **small** **bands** **but** **lived** **in** **a** **large** community **with** **more** elaborate **social** **organization**, **probably** **grouped** **into** clans **of** **people** **of** **common** descent.

**The** flotation samples **from** **the** excavations **allowed** botanists **to** **study** shifts **in** **plant**-**collecting** **habits** **as** **if** **they** **were** **looking** **through** **a** **telescope** **at** **a** **changing** landscape. **Hundreds** **of** **tiny** **plant** **remains** **show** **how** **the** inhabitants **exploited** **nut** **harvests** **in** **nearby** pistachio **and** oak **forests**. **However**, **as** **the** **climate** **dried** **up**, **the** **forests** retreated **from** **the** vicinity **of** **the** **settlement**. **The** inhabitants **turned** **to** **wild** cereal **grasses** **instead**, **collecting** **them** **by** **the** **thousands**, **while** **the** **percentage** **of** **nuts** **in** **the** **diet** **fell**. **By** 8200 B.C., drought **conditions** **were** **so** **severe** **that** **the** **people** **abandoned** **their** **long**-established **settlement**, persing **into** smaller **camps**.

**Five** **centuries** **later**, **about** 7700 B.C., **a** **new** **village** **rose** **on** **the** mound. **At** **first** **the** inhabitants **still** **hunted** gazelle intensively. **Then**, **about** 7000 B.C., **within** **the** **space** **of** **a** **few** **generations**, **they** **switched** abruptly **to** herding domesticated **goats** **and** **sheep** **and** **to** **growing** einkorn, **pulses**, **and** **other** cereal **grasses**. Abu Hureyra **grew** rapidly **until** **it** **covered** **nearly** 30 **acres**. **It** **was** **a** **close**-knit community **of** rectangular, **one**-**story** **mud**-**brick** **houses**, **joined** **by** **narrow** lanes **and** **courtyards**, finally **abandoned** **about** 5000 B.C.. **Many** **complex** factors **led** **to** **the** adoption **of** **the** **new** economies, **not** **only** **at** Abu Hureyra, **but** **at** **many** **other** locations **such** **as** ‘Ain Ghazal, **also** **in** Syria, **where** **goat** toe **bones** **showing** **the** telltale **marks** **of** abrasion **caused** **by** **foot** tethering (binding) testify **to** **early** herding **of** domestic stock.

count: 228

# Official 08-Passage 02 Extinction of the Dinosaurs

Paleozoic Era 334 **to** 248 **million** **years** **ago**

Mesozoic Era 245 **to** 65 **million** **years** **ago**

—Triassic **Period**

—Jurassic **Period**

—Cretaceous **Period**

Cenozoic Era 65 **million** **years** **ago** **to** **the** **present**

Paleontologists **have** **argued** **for** **a** **long** **time** **that** **the** demise **of** **the** **dinosaurs** **was** **caused** **by** climatic alterations **associated** **with** **slow** **changes** **in** **the** **positions** **of** **continents** **and** **seas** **resulting** **from** **plate** tectonics. **Off** **and** **on** **throughout** **the** Cretaceous (**the** **last** **period** **of** **the** Mesozoic era, **during** **which** **dinosaurs** flourished), **large** **shallow** **seas** **covered** extensive **areas** **of** **the** **continents**. **Data** **from** **diverse** sources, **including** geochemical **evidence** **preserved** **in** seafloor sediments, indicate **that** **the** **Late** Cretaceous **climate** **was** milder **than** **today**’s. **The** **days** **were** **not** **too** **hot**, **nor** **the** **nights** **too** **cold**. **The** **summers** **were** **not** **too** **warm**, **nor** **the** **winters** **too** frigid. **The** **shallow** **seas** **on** **the** **continents** **probably** buffered **the** **temperature** **of** **the** **nearby** **air**, **keeping** **it** relatively **constant**.

**At** **the** **end** **of** **the** Cretaceous, **the** geological **record** **shows** **that** **these** seaways retreated **from** **the** **continents** **back** **into** **the** **major** **ocean** **basins**. **No** **one** **knows** **why**. **Over** **a** **period** **of** **about** 100,000 **years**, **while** **the** **seas** **pulled** **back**, **climates** **around** **the** **world** **became** dramatically **more** **extreme**: warmer **days**, cooler **nights**; hotter **summers**, colder **winters**. **Perhaps** **dinosaurs** **could** **not** **tolerate** **these** **extreme** **temperature** **changes** **and** **became** extinct.

**If** **true**, **though**, **why** **did** **cold-blooded** **animals** **such** **as** **snakes**, lizards, turtles, **and** crocodiles **survive** **the** **freezing** **winters** **and** torrid **summers**? **These** **animals** **are** **at** **the** **mercy** **of** **the** **climate** **to** maintain **a** livable body **temperature**. **It**’s **hard** **to** **understand** **why** **they** **would** **not** **be** **affected**, whereas **dinosaurs** **were** **left** **too** crippled **to** cope, **especially** **if**, **as** **some** **scientists** **believe**, **dinosaurs** **were** **warm**-**blooded**. Critics **also** **point** **out** **that** **the** **shallow** seaways **had** retreated **from** **and** **advanced** **on** **the** **continents** numerous **times** **during** **the** Mesozoic, **so** **why** **did** **the** **dinosaurs** **survive** **the** climatic **changes** **associated** **with** **the** earlier fluctuations **but** **not** **with** **this** **one**? **Although** initially **appealing**, **the** hypothesis **of** **a** **simple** climatic **change** **related** **to** **sea** **levels** **is** insufficient **to** **explain** **all** **the** **data**.

Dissatisfaction **with** **conventional** **explanations** **for** **dinosaur** extinctions **led** **to** **a** **surprising** observation **that**, **in** **turn**, **has** **suggested** **a** **new** hypothesis. **Many** **plants** **and** **animals** **disappear** abruptly **from** **the** fossil **record** **as** **one** **moves** **from** layers **of** **rock** **documenting** **the** **end** **of** **the** Cretaceous **up** **into** **rocks** **representing** **the** **beginning** **of** **the** Cenozoic (**the** era after **the** Mesozoic). **Between** **the** **last** layer **of** Cretaceous **rock** **and** **the** **first** layer **of** Cenozoic **rock**, **there** **is** **often** **a** **thin** layer **of** **clay**. **Scientists** **felt** **that** **they** **could** **get** an **idea** **of** **how** **long** **the** extinctions **took** **by** **determining** **how** **long** **it** **took** **to** **deposit** **this** **one** centimeter **of** **clay** **and** **they** **thought** **they** **could** **determine** **the** **time** **it** **took** **to** **deposit** **the** **clay** **by** **determining** **the** **amount** **of** **the** element iridium (Ir) **it** **contained**.

Ir **has** **not** **been** **common** **at** **Earth**’s **surface** **since** **the** **very** **beginning** **of** **the** **planet**’s **history**. **Because** **it** **usually** **exists** **in** **a** metallic **state**, **it** **was** preferentially incorporated **in** **Earth**’s core **as** **the** **planet** **cooled** **and** consolidated. Ir **is** **found** **in** **high** concentrations **in** **some** meteorites, **in** **which** **the** **solar** **system**’s original **chemical** **composition** **is** **preserved**. **Even** **today**, microscopic meteorites continually bombard **Earth**, **falling** **on** **both** **land** **and** **sea**. **By** **measuring** **how** **many** **of** **these** meteorites **fall** **to** **Earth** **over** **a** **given** **period** **of** **time**, **scientists** **can** estimate **how** **long** **it** **might** **have** **taken** **to** **deposit** **the** **observed** **amount** **of** Ir **in** **the** **boundary** **clay**. **These** calculations **suggest** **that** **a** **period** **of** **about** **one** **million** **years** **would** **have** **been** **required**. **However**, **other** **reliable** **evidence** **suggests** **that** **the** deposition **of** **the** **boundary** **clay** **could** **not** **have** **taken** **one** **million** **years**. **So** **the** unusually **high** concentration **of** Ir **seems** **to** **require** **a** **special** **explanation**.

**In** **view** **of** **these** **facts**, **scientists** hypothesized **that** **a** **single** **large** asteroid, **about** 10 **to** 15 kilometers **across**, collided **with** **Earth**, **and** **the** **resulting** fallout **created** **the** **boundary** **clay**. **Their** calculations **show** **that** **the** impact **kicked** **up** **a** **dust** **cloud** **that** **cut** **off** **sunlight** **for** **several** **months**, inhibiting photosynthesis **in** **plants**; **decreased** **surface** **temperatures** **on** **continents** **to** **below** **freezing**; **caused** **extreme** episodes **of** **acid** **rain**; **and** significantly **raised** **long**-**term** global **temperatures** **through** **the** greenhouse **effect**. **This** disruption **of** **food** **chain** **and** **climate** **would** **have** eradicated **the** **dinosaurs** **and** **other** organisms **in** **less** **than** **fifty** **years**.

count: 227

# Official 07-Passage 02 Ancient Rome and Greece

**There** **is** **a** **quality** **of** cohesiveness **about** **the** Roman **world** **that** **applied** **neither** **to** **Greece** **nor** **perhaps** **to** **any** **other** **civilization**, **ancient** **or** **modern**. **Like** **the** **stones** **of** **a** Roman **wall**, **which** **were** **held** **together** **both** **by** **the** regularity **of** **the** **design** **and** **by** **that** peculiarly **powerful** Roman cement, **so** **the** **various** **parts** **of** **the** Roman realm **were** **bonded** **into** **a** massive, monolithic entity **by** **physical**, organizational, **and** psychological **controls**. **The** **physical** **bonds** **included** **the** **network** **of** military garrisons, **which** **were** **stationed** **in** **every** **province**, **and** **the** **network** **of** **stone**-**built** **roads** **that** **linked** **the** **provinces** **with** Rome. **The** organizational **bonds** **were** **based** **on** **the** **common** **principles** **of** **law** **and** **administration** **and** **on** **the** **universal** **army** **of** **officials** **who** enforced **common** **standards** **of** **conduct**. **The** psychological **controls** **were** **built** **on** **fear** **and** **punishment**—**on** **the** **absolute** certainty **that** **anyone** **or** **anything** **that** threatened **the** **authority** **of** Rome **would** **be** utterly **destroyed**.

**The** source **of** **the** Roman obsession **with** unity **and** cohesion may **well** **have** **lain** **in** **the** **pattern** **of** Rome’s **early** **development**. Whereas **Greece** **had** **grown** **from** **scores** **of** scattered **cities**, Rome **grew** **from** **one** **single** organism. **While** **the** **Greek** **world** **had** **expanded** **along** **the** Mediterranean **sea** lanes, **the** Roman **world** **was** assembled **by** territorial conquest. **Of** **course**, **the** contrast **is** **not** **quite** **so** stark: **in** Alexander **the** **Great** **the** Greeks **had** **found** **the** greatest territorial conqueror **of** **all** **time**; **and** **the** Romans, **once** **they** **moved** **outside** **Italy**, **did** **not** **fail** **to** **learn** **the** **lessons** **of** **sea** **power**. **Yet** **the** essential **difference** **is** undeniable. **The** **key** **to** **the** **Greek** **world** **lay** **in** **its** **high**-**powered** **ships**; **the** **key** **to** Roman **power** **lay** **in** **its** **marching** legions. **The** Greeks **were** wedded **to** **the** **sea**; **the** Romans, **to** **the** **land**. **The** **Greek** **was** **a** **sailor** **at** **heart**; **the** Roman, **a** landsman.

**Certainly**, **in** **trying** **to** **explain** **the** Roman **phenomenon**, **one** **would** **have** **to** **place** **great** emphasis **on** **this** **almost** **animal** instinct **for** **the** territorial imperative. Roman priorities **lay** **in** **the** **organization**, exploitation, **and** defense **of** **their** territory. **In** **all** probability **it** **was** **the** fertile **plain** **of** Latium, **where** **the** Latins **who** **founded** Rome originated, **that** **created** **the** **habits** **and** **skills** **of** **landed** **settlement**, **landed** property, **landed** economy, **landed** **administration**, **and** **a** **land**-**based** **society**. **From** **this** **arose** **the** Roman genius **for** military **organization** **and** orderly **government**. **In** **turn**, **a** **deep** attachment **to** **the** **land**, **and** **to** **the** stability **which** rural **life** engenders, fostered **the** Roman **virtues**: gravitas, **a** **sense** **of** **responsibility**, peitas, **a** **sense** **of** **devotion** **to** **family** **and** **country**, **and** iustitia, **a** **sense** **of** **the** **natural** **order**.

**Modern** **attitudes** **to** Roman **civilization** **range** **from** **the** infinitely **impressed** **to** **the** thoroughly disgusted. **As** **always**, **there** **are** **the** **power** worshippers, **especially** **among** historians, **who** **are** predisposed **to** **admire** **whatever** **is** **strong**, **who** **feel** **more** **attracted** **to** **the** **might** **of** Rome **than** **to** **the** subtlety **of** **Greece**. **At** **the** **same** **time**, **there** **is** **a** **solid** body **of** **opinion** **that** **dislikes** Rome. **For** **many**, Rome **is** **at** **best** **the** imitator **and** **the** continuator **of** **Greece** **on** **a** larger scale. **Greek** **civilization** **had** **quality**; Rome, mere **quantity**. **Greece** **was** original; Rome, derivative. **Greece** **had** **style**; Rome **had** **money**. **Greece** **was** **the** **inventor**; Rome, **the** **research** **and** **development** **division**. **Such** **indeed** **was** **the** **opinion** **of** **some** **of** **the** **more** intellectual Romans. “**Had** **the** Greeks **held** novelty **in** **such** disdain **as** **we**,” **asked** Horace **in** **his** Epistles, “**what** **work** **of** **ancient** **date** **would** **now** **exist**?”

Rome’s **debt** **to** **Greece** **was** enormous. **The** Romans **adopted** **Greek** **religion** **and** **moral** philosophy. **In** **literature**, **Greek** writers **were** consciously **used** **as** **models** **by** **their** Latin successors. **It** **was** absolutely **accepted** **that** an **educated** Roman **should** **be** **fluent** **in** **Greek**. **In** speculative philosophy **and** **the** **sciences**, **the** Romans **made** virtually **no** **advance** **on** **early** **achievements**.

**Yet** **it** **would** **be** **wrong** **to** **suggest** **that** Rome **was** somehow **a** **junior** **partner** **in** Greco-Roman **civilization**. **The** Roman genius **was** **projected** **into** **new** spheres—**especially** **into** **those** **of** **law**, military **organization**, **administration**, **and** **engineering**. Moreover, **the** **tensions** **that** **arose** **within** **the** Roman **state** **produced** **literary** **and** artistic sensibilities **of** **the** highest **order**. **It** **was** **no** **accident** **that** **many** **leading** Roman **soldiers** **and** **statesmen** **were** writers **of** **high** caliber.

count: 226

# Official 11-Passage 01 Ancient Egyptian Sculpture

**In** **order** **to** **understand** **ancient** **Egyptian** **art**, **it** **is** **vital** **to** **know** **as** **much** **as** **possible** **of** **the** elite **Egyptians**’ **view** **of** **the** **world** **and** **the** **functions** **and** contexts **of** **the** formal **art** **produced** **for** **them**. **Without** **this** **knowledge** **we** **can** **appreciate** **only** **the** formal **content** **of** **Egyptian** **art**, **and** **we** **will** **fail** **to** **understand** **why** **it** **was** **produced** **or** **the** **concepts** **that** **shaped** **it** **and** **caused** **it** **to** **adopt** **its** distinctive **forms**. **In** **fact**, **a** **lack** **of** **understanding** **concerning** **the** **purposes** **of** **Egyptian** **art** **has** **often** **led** **it** **to** **be** **compared** unfavorably **with** **the** **art** **of** **other** **cultures**: **Why** **did** **the** **Egyptians** **not** **develop** **sculpture** **in** **which** **the** body **turned** **and** **twisted** **through** **space** **like** **classical** **Greek** statuary? **Why** **do** **the** **artists** **seem** **to** **get** **left** **and** **right** **confused**? **And** **why** **did** **they** **not** **discover** **the** geometric perspective **as** **European** **artists** **did** **in** **the** Renaissance? **The** **answer** **to** **such** **questions** **has** **nothing** **to** **do** **with** **a** **lack** **of** **skill** **or** imagination **on** **the** **part** **of** **Egyptian** **artists** **and** **everything** **to** **do** **with** **the** **purposes** **for** **which** **they** **were** **producing** **their** **art**.

**The** **majority** **of** **three**-dimensional representations, **whether** **standing**, **seated**, **or** kneeling, exhibit **what** **is** **called** frontality: **they** **face** **straight** **ahead**, **neither** **twisting** **nor** **turning**. **When** **such** **statues** **are** **viewed** **in** isolation, **out** **of** **their** original context **and** **without** **knowledge** **of** **their** **function**, **it** **is** **easy** **to** criticize **them** **for** **their** **rigid** **attitudes** **that** **remained** unchanged **for** **three** **thousand** **years**. Frontality **is**, **however**, directly **related** **to** **the** **functions** **of** **Egyptian** statuary **and** **the** contexts **in** **which** **the** **statues** **were** **set** **up**. **Statues** **were** **created** **not** **for** **their** decorative **effect** **but** **to** **play** **a** **primary** **role** **in** **the** cults **of** **the** **gods**, **the** **king**, **and** **the** **dead**. **They** **were** **designed** **to** **be** **put** **in** **places** **where** **these** **beings** **could** manifest **themselves** **in** **order** **to** **be** **the** recipients **of** ritual **actions**. **Thus** **it** **made** **sense** **to** **show** **the** **statue** **looking** **ahead** **at** **what** **was** **happening** **in** **front** **of** **it**, **so** **that** **the** **living** **performer** **of** **the** ritual **could** interact **with** **the** divine **or** deceased recipient. **Very** **often** **such** **statues** **were** enclosed **in** rectangular shrines **or** **wall** niches **whose** **only** **opening** **was** **at** **the** **front**, **making** **it** **natural** **for** **the** **statue** **to** display frontality. **Other** **statues** **were** **designed** **to** **be** **placed** **within** an architectural **setting**, **for** instance, **in** **front** **of** **the** monumental **entrance** gateways **to** **temples** **known** **as** pylons, **or** **in** pillared **courts**, **where** **they** **would** **be** **placed** **against** **or** **between** pillars: **their** frontality worked perfectly **within** **the** architectural context.

**Statues** **were** normally **made** **of** **stone**, **wood**, **or** **metal**. **Stone** **statues** **were** worked **from** **single** rectangular **blocks** **of** **material** **and** retained **the** compactness **of** **the** original **shape**. **The** **stone** **between** **the** **arms** **and** **the** body **and** **between** **the** **legs** **in** **standing** **figures** **or** **the** **legs** **and** **the** **seat** **in** **seated** **ones** **was** **not** normally **cut** **away**. **From** **a** **practical** **aspect** **this** **protected** **the** **figures** **against** breakage **and** psychologically **gives** **the** images **a** **sense** **of** **strength** **and** **power**, **usually** enhanced **by** **a** **supporting** **back** pillar. **By** contrast, **wooden** **statues** **were** **carved** **from** **several** **pieces** **of** **wood** **that** **were** pegged **together** **to** **form** **the** **finished** **work**, **and** **metal** **statues** **were** **either** **made** **by** wrapping **sheet** **metal** **around** **a** **wooden** core **or** **cast** **by** **the** **lost** **wax** **process**

**Apart** **from** **statues** **representing** deities, **kings**, **and** **named** **members** **of** **the** elite **that** **can** **be** **called** formal, **there** **is** **another** **group** **of** **three**-dimensional representations **that** depicts generic **figures**, frequently **servants**, **from** **the** nonelite **population**. **The** **function** **of** **these** **is** **quite** **different**. **Many** **are** **made** **to** **be** **put** **in** **the** **tombs** **of** **the** elite **in** **order** **to** **serve** **the** **tomb** **owners** **in** **the** afterlife. **Unlike** formal **statues** **that** **are** **limited** **to** static poses **of** **standing**, **sitting**, **and** kneeling, **these** **figures** depict **a** **wide** **range** **of** **actions**, **such** **as** grinding **grain**, **baking** **bread**, **producing** **pots**, **and** **making** **music**, **and** **they** **are** **shown** **in** **appropriate** poses, **bending** **and** squatting **as** **they** **carry** **out** **their** **tasks**.

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**lost** **wax** **process**: an **ancient** **method** **of** **casting** **using** **a** **wax** **model** **and** **clay** mold

count: 225

# Official 04-Passage 03 Petroleum Resources

Petroleum, **consisting** **of** crude **oil** **and** **natural** **gas**, **seems** **to** originate **from** organic **matter** **in** marine sediment. Microscopic organisms **settle** **to** **the** seafloor **and** **accumulate** **in** marine **mud**. **The** organic **matter** may partially decompose, **using** **up** **the** dissolved **oxygen** **in** **the** sediment. **As** **soon** **as** **the** **oxygen** **is** **gone**, decay **stops** **and** **the** **remaining** organic **matter** **is** **preserved**.

**Continued** sedimentation—**the** **process** **of** **deposits**’ **settling** **on** **the** **sea** **bottom**—**buries** **the** organic **matter** **and** **subjects** **it** **to** higher **temperatures** **and** **pressures**, **which** convert **the** organic **matter** **to** **oil** **and** **gas**. **As** **muddy** sediments **are** **pressed** **together**, **the** **gas** **and** **small** droplets **of** **oil** may **be** **squeezed** **out** **of** **the** **mud** **and** may **move** **into** sandy layers **nearby**. **Over** **long** **periods** **of** **time** (**millions** **of** **years**), accumulations **of** **gas** **and** **oil** **can** **collect** **in** **the** sandy layers. **Both** **oil** **and** **gas** **are** **less** dense **than** **water**, **so** **they** generally **tend** **to** **rise** **upward** **through** **water**-saturated **rock** **and** sediment.

**Oil** **pools** **are** **valuable** **underground** accumulations **of** **oil**, **and** **oil** **fields** **are** regions underlain **by** **one** **or** **more** **oil** **pools**. **When** an **oil** **pool** **or** **field** **has** **been** **discovered**, **wells** **are** **drilled** **into** **the** **ground**. **Permanent** **towers**, **called** derricks, **used** **to** **be** **built** **to** **handle** **the** **long** **sections** **of** **drilling** **pipe**. **Now** **portable** **drilling** **machines** **are** **set** **up** **and** **are** **then** dismantled **and** **removed**. **When** **the** **well** **reaches** **a** **pool**, **oil** **usually** **rises** **up** **the** **well** **because** **of** **its** density **difference** **with** **water** **beneath** **it** **or** **because** **of** **the** **pressure** **of** **expanding** **gas** **trapped** **above** **it**. **Although** **this** **rise** **of** **oil** **is** **almost** **always** carefully **controlled** **today**, spouts **of** **oil**, **or** gushers, **were** **common** **in** **the** **past**. **Gas** **pressure** **gradually** **dies** **out**, **and** **oil** **is** **pumped** **from** **the** **well**. **Water** **or** **steam** may **be** **pumped** **down** adjacent **wells** **to** **help** **push** **the** **oil** **out**. **At** **a** refinery, **the** crude **oil** **from** **underground** **is** **separated** **into** **natural** **gas**, gasoline, kerosene, **and** **various** **oils**. Petrochemicals **such** **as** dyes, fertilizer, **and** **plastic** **are** **also** manufactured **from** **the** petroleum.

**As** **oil** **becomes** increasingly **difficult** **to** **find**, **the** **search** **for** **it** **is** extended **into** **more**-hostile **environments**. **The** **development** **of** **the** **oil** **field** **on** **the** **North** Slope **of** Alaska **and** **the** **construction** **of** **the** Alaska pipeline **are** **examples** **of** **the** **great** **expense** **and** **difficulty** involved **in** **new** **oil** **discoveries**. **Offshore** **drilling** **platforms** extend **the** **search** **for** **oil** **to** **the** **ocean**’s continental **shelves**—**those** gently sloping submarine regions **at** **the** **edges** **of** **the** **continents**. **More** **than** **one**-**quarter** **of** **the** **world**’s **oil** **and** **almost** **one**-**fifth** **of** **the** **world**’s **natural** **gas** **come** **from** **offshore**, **even** **though** **offshore** **drilling** **is** **six** **to** **seven** **times** **more** **expensive** **than** **drilling** **on** **land**. **A** significant **part** **of** **this** **oil** **and** **gas** **comes** **from** **under** **the** **North** **Sea** **between** **Great** **Britain** **and** Norway.

**Of** **course**, **there** **is** **far** **more** **oil** **underground** **than** **can** **be** **recovered**. **It** may **be** **in** **a** **pool** **too** **small** **or** **too** **far** **from** **a** **potential** **market** **to** justify **the** **expense** **of** **drilling**. **Some** **oil** **lies** **under** regions **where** **drilling** **is** **forbidden**, **such** **as** **national** **parks** **or** **other** **public** **lands**. **Even** **given** **the** **best** extraction **techniques**, **only** **about** 30 **to** 40 **percent** **of** **the** **oil** **in** **a** **given** **pool** **can** **be** **brought** **to** **the** **surface**. **The** **rest** **is** **far** **too** **difficult** **to** extract **and** **has** **to** **remain** **underground**.

Moreover, **getting** petroleum **out** **of** **the** **ground** **and** **from** **under** **the** **sea** **and** **to** **the** consumer **can** **create** environmental **problems** **anywhere** **along** **the** **line**. Pipelines **carrying** **oil** **can** **be** **broken** **by** **faults** **or** landslides, **causing** **serious** **oil** spills. Spillage **from** **huge** **oil**-**carrying** cargo **ships**, **called** **tankers**, involved **in** **collisions** **or** accidental groundings (**such** **as** **the** **one** **off** Alaska **in** 1989) **can** **create** **oil** slicks **at** **sea**. **Offshore** **platforms** may **also** **lose** **oil**, **creating** **oil** slicks **that** drift ashore **and** foul **the** **beaches**, **harming** **the** **environment**. **Sometimes**, **the** **ground** **at** an **oil** **field** may subside **as** **oil** **is** **removed**. **The** Wilmington **field** **near** **Long** **Beach**, California, **has** subsided **nine** meters **in** 50 **years**; protective **barriers** **have** **had** **to** **be** **built** **to** **prevent** seawater **from** **flooding** **the** **area**. Finally, **the** refining **and** **burning** **of** petroleum **and** **its** **products** **can** **cause** **air** **pollution**. **Advancing** **technology** **and** **strict** **laws**, **however**, **are** **helping** **control** **some** **of** **these** adverse environmental **effects**.

count: 225

# Official 41-Passage 01 Navajo Art

**The** Navajo, **a** **Native** **American** **people** **living** **in** **the** southwestern **United** **States**, **live** **in** **small** scattered **settlements**. **In** **many** **respects**, **such** **as** **education**, **occupation**, **and** leisure **activities**, **their** **life** **is** **like** **that** **of** **other** **groups** **that** **contribute** **to** **the** **diverse** **social** fabric **of** **North** **American** **culture** **in** **the** **twenty-first** **century**. **At** **the** **same** **time**, **they** **have** retained **some** **traditional** cultural **practices** **that** **are** **associated** **with** **particular** **art** **forms**. **For** **example**, **the** **most** **important** **traditional** Navajo rituals **include** **the** **production** **of** **large** **floor** **paintings**. **These** **are** actually **made** **by** **pouring** **thin**, finely **controlled** **streams** **of** colored **sands** **or** pulverized **vegetable** **and** **mineral** substances, pollen, **and** **flowers** **in** **precise** **patterns** **on** **the** **ground**.**The** largest **of** **these** **paintings** may **be** **up** **to** 5.5 meters **in** diameter **and** **cover** **the** **entire** **floor** **of** **a** **room**. **Working** **from** **the** **inside** **of** **the** **design** **outward**, **the** Navajo **artist** **and** **his** **assistants** **will** sift **the** **black**, **white**, bluish-gray, **orange**, **and** **red** **materials** **through** **their** **fingers** **to** **create** **the** finely detailed imagery. **The** **paintings** **and** **chants** **used** **in** **the** **ceremonies** **are** **directed** **by** **well**-**trained** **artists** **and** **singers** **who** enlist **the** **aid** **of** **spirits** **who** **are** impersonated **by** **masked** **performers**. **The** **twenty**-**four** **known** Navajo **chants** **can** **be** **represented** **by** **up** **to** 500 **sand** **paintings**. **These** **complex** **paintings** **serve** **as** **memory** **aids** **to** **guide** **the** **singers** **during** **the** **performance** **of** **the** ritual **songs**, **which** **can** **last** **up** **to** **nine** **days**.

**The** **purpose** **and** **meaning** **of** **the** **sand** **paintings** **can** **be** **explained** **by** **examining** **one** **of** **the** **most** **basic** ideals **of** Navajo **society**, embodied **in** **their** **word** hozho (**beauty** **or** **harmony**, **goodness**, **and** **happiness**). **It** coexists **with** hochxo (“ugliness,” **or** “evil,” **and** “disorder”) **in** **a** **world** **where** **opposing** **forces** **of** dynamism **and** stability **create** **constant** **change**. **When** **the** **world**, **which** **was** **created** **in** **beauty**, **becomes** **ugly** **and** disorderly, **the** Navajo **gather** **to** **perform** rituals **with** **songs** **and** **make** **sand** **paintings** **to** restore **beauty** **and** **harmony** **to** **the** **world**. **Some** **illness** **is** **itself** **regarded** **as** **a** **type** **of** disharmony. **Thus**, **the** restoration **of** **harmony** **through** **a** **ceremony** **can** **be** **part** **of** **a** **curing** **process**.

**Men** **make** **sand** **paintings** **that** **are** accurate **copies** **of** **paintings** **from** **the** **past**. **The** **songs** **sung** **over** **the** **paintings** **are** **also** faithful renditions **of** **songs** **from** **the** **past**. **By** re-**creating** **these** **arts**, **which** **reflect** **the** original **beauty** **of** creation, **the** Navajo **bring** **beauty** **to** **the** **present** **world**. **As** **relative** newcomers **to** **the** **Southwest**, **a** **place** **where** **their** **climate**, neighbors, **and** **rulers** **could** **be** equally inhospitable, **the** Navajo **created** **these** **art** **forms** **to** **affect** **the** **world** **around** **them**, **not** **just** **through** **the** recounting **of** **the** **actions** symbolized, **but** **through** **the** **beauty** **and** **harmony** **of** **the** artworks **themselves**. **The** **paintings** generally illustrate **ideas** **and** **events** **from** **the** **life** **of** **a** mythical **hero**, **who**, after **being** healed **by** **the** **gods**, **gave** **gifts** **of** **songs** **and** **paintings**. **Working** **from** **memory**, **the** **artists** re-**create** **the** **traditional** **form** **of** **the** image **as** accurately **as** **possible**.

**The** Navajo **are** **also** **world-famous** **for** **the** **designs** **on** **their** woven **blankets**. Navajo **women** **own** **the** **family** flocks, **control** **the** shearing **of** **the** **sheep**, **the** **carding**, **the** **spinning**, **and** **dying** **of** **the** **thread**, **and** **the** weaving **of** **the** fabrics. **While** **the** **men** **who** **make** faithful **copies** **of** **sand** **paintings** **from** **the** **past** **represent** **the** **principle** **of** stability **in** Navajo **thought**, **women** embody dynamism **and** **create** **new** **designs** **for** **every** weaving **they** **make**. Weaving **is** **a** paradigm **of** **the** creativity **of** **a** mythic **ancestor** **named** Spider **Woman** **who** wove **the** **universe** **as** **a** cosmic **web** **that** **united** **earth** **and** **sky**. **It** **was** **she** **who**, **according to** legend, **taught** Navajo **women** **how** **to** weave. **As** **they** **prepare** **their** **materials** **and** weave, Navajo **women** imitate **the** transformations **that** originally **created** **the** **world**. **Working** **on** **their** looms, Navajo weavers **create** images **through** **which** **they** **experience** **harmony** **with** **nature**. **It** **is** **their** **means** **of** **creating** **beauty** **and** thereby **contributing** **to** **the** **beauty**, **harmony**, **and** healing **of** **the** **world**. **Thus**, weaving **is** **a** **way** **of** **seeing** **the** **world** **and** **being** **part** **of** **it**.

count: 224

# Official 34-Passage 03 The Development of Steam Power

**By** **the** eighteenth **century**, **Britain** **was** **experiencing** **a** **severe** shortage **of** energy. **Because** **of** **the** **growth** **of** **population**, **most** **of** **the** **great** **forests** **of** medieval **Britain** **had** **long** **ago** **been** **replaced** **by** **fields** **of** **grain** **and** **hay**. **Wood** **was** **in** **ever**-shorter **supply**, **yet** **it** **remained** tremendously **important**. **It** **served** **as** **the** **primary** source **of** **heat** **for** **all** **homes** **and** **industries** **and** **as** **a** **basic** **raw material**. **Processed** **wood** (charcoal) **was** **the** **fuel** **that** **was** **mixed** **with** **iron** ore **in** **the** blast furnace **to** **produce** **pig** **iron** (**raw** **iron**). **The** **iron** **industry**’s **appetite** **for** **wood** **was** enormous, **and** **by** 1740 **the British** **iron** **industry** **was** stagnating. **Vast** **forests** enabled **Russia** **to** **become** **the** **world**’s **leading** producer **of** **iron**, **much** **of** **which** **was** **exported** **to** **Britain**. **But** **Russia**’s **potential** **for** **growth** **was** **limited** **too**, **and** **in** **a** **few** **decades** **Russia** **would** **reach** **the** **barrier** **of** inadequate energy **that** **was** **already** **holding** **England** **back**.

**As** **this** **early** energy crisis **grew** **worse**, **Britain** **looked** **toward** **its** **abundant** **and** widely scattered **reserves** **of** **coal** **as** an **alternative** **to** **its** vanishing **wood**. **Coal** **was** **first** **used** **in** **Britain** **in** **the** **late** **Middle** **Ages** **as** **a** source **of** **heat**. **By** 1640 **most** **homes** **in** **London** **were** **heated** **with** **it**, **and** **it** **also** **provided** **heat** **for** **making** **beer**, **glass**, **soap**, **and** **other** **products**. **Coal** **was** **not** **used**, **however**, **to** **produce** mechanical energy **or** **to** **power** machinery. **It** **was** **there** **that** **coal**’s **potential** **was** enormous.

**As** **more** **coal** **was** **produced**, **mines** **were** **dug** deeper **and** deeper **and** **were** constantly **filling** **with** **water**. Mechanical **pumps**, **usually** **powered** **by** **hundreds** **of** **horses** **walking** **in** **circles** **at** **the** **surface**, **had** **to** **be** installed. **Such** **power** **was** **expensive** **and** bothersome. **In** an **attempt** **to** **overcome** **these** **disadvantages**, Thomas Savery **in** 1698 **and** Thomas Newcomen **in** 1705 **invented** **the** **first** **primitive** **steam** **engines**. **Both** **engines** **were** **extremely** inefficient. **Both** **burned** **coal** **to** **produce** **steam**, **which** **was** **then** **used** **to** **operate** **a** **pump**. **However**, **by** **the** **early** 1770s, **many** **of** **the** Savery **engines** **and** **hundreds** **of** **the** Newcomen **engines** **were** **operating** successfully, **though** inefficiently, **in** **English** **and** **Scottish** **mines**.

**In** **the** **early** 1760s, **a** **gifted** **young** Scot **named** James Watt **was** **drawn** **to** **a** critical **study** **of** **the** **steam** **engine**. Watt **was** **employed** **at** **the** **time** **by** **the** **University** **of** Glasgow **as** **a** **skilled** crafts **worker** **making** **scientific** **instruments**. **In** 1763, Watt **was** **called** **on** **to** **repair** **a** Newcomen **engine** **being** **used** **in** **a** **physics** **course**. After **a** series **of** observations, Watt **saw** **that** **the** Newcomen’s **waste** **of** energy **could** **be** **reduced** **by** **adding** **a** **separate** condenser. **This** **splendid** **invention**, **patented** **in** 1769, greatly **increased** **the** efficiency **of** **the** **steam** **engine**. **The** **steam** **engine** **of** Watt **and** **his** followers **was** **the** technological **advance** **that** **gave** **people**, **at** **least** **for** **a** **while**, unlimited **power** **and** **allowed** **the** **invention** **and** **use** **of** **all** **kinds** **of** **power** **equipment**.

**The** **steam** **engine** **was** quickly **put** **to** **use** **in** **several** **industries** **in** **Britain**. **It** drained **mines** **and** **made** **possible** **the** **production** **of** **ever** **more** **coal** **to** **feed** **steam** **engines** elsewhere. **The** **steam** **power** **plant** **began** **to** **replace** waterpower **in** **the** **cotton**-**spinning** mills **as** **well** **as** **other** **industries** **during** **the** 1780s, **contributing** **to** **a** phenomenal **rise** **in** industrialization. **The** **British** **iron** **industry** **was** radically **transformed**. **The** **use** **of** **powerful**, **steam**-**driven** bellows **in** blast furnaces **helped** **iron** makers **switch** **over** rapidly **from** **limited** charcoal **to** unlimited **coke** (**which** **is** **made** **from** **coal**) **in** **the** smelting **of** **pig** **iron** (**the** **process** **of** refining impure **iron**) after 1770. **In** **the** 1780s, Henry Cort **developed** **the** puddling furnace, **which** **allowed** **pig** **iron** **to** **be** refined **in** **turn** **with** **coke**. Cort **also** **developed** **heavy**-**duty**, **steam**-**powered** **rolling** mills, **which** **were** capable **of** **producing** **finished** **iron** **in** **every** **shape** **and** **form**.

**The** economic **consequence** **of** **these** **technical** innovations **in** **steam** **power** **was** **a** **great** **boom** **in** **the British** **iron** **industry**. **In** 1740 **annual** **British** **iron** **production** **was** **only** 17,000 **tons**, **but** **by** 1844, **with** **the** **spread** **of** **coke** smelting **and** **the** impact **of** Cort’s **inventions**, **it** **had** **increased** **to** 3,000,000 **tons**. **This** **was** **a** **truly** **amazing** expansion. **Once** scarce **and** **expensive**, **iron** **became** **cheap**, **basic**, **and** indispensable **to** **the** economy.

count: 224

# Official 40-Passage 01 Ancient Athens

**One** **of** **the** **most** **important** **changes** **in** **Greece** **during** **the** **period** **from** 800 B.C. **to** 500 B.C. **was** **the** **rise** **of** **the** polis, **or** **city**-**state**, **and** **each** polis **developed** **a** **system** **of** **government** **that** **was** **appropriate** **to** **its** **circumstances**. **The** **problems** **that** **were** **faced** **and** solved **in** Athens **were** **the** **sharing** **of** **political** **power** **between** **the** established aristocracy **and** **the** emerging **other** **classes**, **and** **the** **adjustment** **of** aristocratic **ways** **of** **life** **to** **the** **ways** **of** **life** **of** **the** **new** polis. **It** **was** **the** harmonious blending **of** **all** **of** **these** elements **that** **was** **to** **produce** **the** **classical** **culture** **of** Athens.

**Entering** **the** polis **age**, Athens **had** **the** **traditional** **institutions** **of** **other** **Greek** protodemocratic **states**: an assembly **of** **adult** **males**, an aristocratic council, **and** annually **elected** **officials**. **Within** **this** **traditional** **framework** **the** Athenians, **between** 600 B.C. **and** 450 B.C., evolved **what** Greeks **regarded** **as** **a** fully fledged democratic **constitution**, **though** **the** **right** **to** **vote** **was** **given** **to** fewer **groups** **of** **people** **than** **is** **seen** **in** **modern** **times**.

**The** **first** **steps** **toward** **change** **were** **taken** **by** Solon **in** 594 B.C., **when** **he** **broke** **the** aristocracy’s stranglehold **on** **elected** **offices** **by** establishing **wealth** **rather** **than** **birth** **as** **the** **basis** **of** **office** **holding**, **abolishing** **the** economic obligations **of** **ordinary** Athenians **to** **the** aristocracy, **and** **allowing** **the** assembly (**of** **which** **all** **citizens** **were** **equal** **members**) **to** overrule **the** **decisions** **of** **local** **courts** **in** **certain** **cases**. **The** **strength** **of** **the** Athenian aristocracy **was** further weakened **during** **the** **rest** **of** **the** **century** **by** **the** **rise** **of** **a** **type** **of** **government** **known** **as** **a** tyranny, **which** **is** **a** **form** **of** interim **rule** **by** **a** **popular** strongman (**not** **rule** **by** **a** ruthless dictator **as** **the** **modern** **use** **of** **the** **term** **suggests** **to** us). **The** Peisistratids, **as** **the** succession **of** tyrants **were** **called** (after **the** founder **of** **the** dynasty, Peisistratos), **strengthened** Athenian **central** **administration** **at** **the** **expense** **of** **the** aristocracy **by** **appointing** **judges** **throughout** **the** region, **producing** Athens’ **first** **national** coinage, **and** **adding** **and** embellishing **festivals** **that** **tended** **to** **focus** **attention** **on** Athens **rather** **than** **on** **local** **villages** **of** **the** **surrounding** region. **By** **the** **end** **of** **the** **century**, **the** **time** **was** **ripe** **for** **more** **change**: **the** tyrants **were** **driven** **out**, **and** **in** 508 B.C. **a** **new** reformer, Cleisthenes, **gave** **final** **form** **to** **the** **developments** **reducing** aristocratic **control** **already** **under** **way**.

Cleisthenes’ principal **contribution** **to** **the** creation **of** democracy **at** Athens **was** **to** **complete** **the** **long** **process** **of** weakening **family** **and** clan structures, **especially** **among** **the** aristocrats, **and** **to** **set** **in** **their** **place** locality-**based** **corporations** **called** demes, **which** **became** **the** **point** **of** **entry** **for** **all** civic **and** **most** **religious** **life** **in** Athens. **Out** **of** **the** demes **were** **created** 10 **artificial** tribes **of** roughly **equal** **population**. **From** **the** demes, **by** **either** election **or** selection, **came** 500 **members** **of** **a** **new** council, 6,000 jurors **for** **the** **courts**, 10 **generals**, **and** **hundreds** **of** commissioners. **The** assembly **was** sovereign **in** **all** **matters** **but** **in** **practice** delegated **its** **power** **to** subordinate bodies **such** **as** **the** council, **which** **prepared** **the** **agenda** **for** **the** **meetings** **of** **the** assembly, **and** **the** **courts**, **which** **took** **care** **of** **most** judicial **matters**. **Various** **committees** **acted** **as** an executive **branch**, implementing **policies** **of** **the** assembly **and** supervising, **for** instance, **the** **food** **and** **water** **supplies** **and** **public** **buildings**. **This** **wide**-scale participation **by** **the** citizenry **in** **the** **government** **distinguished** **the** democratic **form** **of** **the** Athenian polis **from** **other**, **less** liberal **forms**.

**The** **effect** **of** Cleisthenes’ **reforms** **was** **to** establish **the** superiority **of** **the** Athenian community **as** **a** **whole** **over** **local** **institutions** **without** **destroying** **them**. **National** **politics** **rather** **than** **local** **or** deme **politics** **became** **the** focal **point**. **At** **the** **same** **time**, **entry** **into** **national** **politics** **began** **at** **the** deme **level** **and** **gave** **local** loyalty **a** **new** **focus**: Athens **itself**. **Over** **the** **next** **two** **centuries** **the** implications **of** Cleisthenes’ **reforms** **were** fully **exploited**.

**During** **the** **fifth** **century** B.C. **the** council **of** 500 **was** **extremely** influential **in** **shaping** **policy**. **In** **the** **next** **century**, **however**, **it** **was** **the** **mature** assembly **that** **took** **on** **decision**-**making** **responsibility**. **By** **any** **measure** **other** **than** **that** **of** **the** aristocrats, **who** **had** **been** upstaged **by** **the** supposedly inferior “**people**,” **the** Athenian democracy **was** **a** stunning **success**. **Never** **before**, **or** **since**, **have** **so** **many** **people** **been** involved **in** **the** **serious** **business** **of** **self**-governance. **It** **was** precisely **this** opportunity **to** **participate** **in** **public** **life** **that** **provided** **a** stimulus **for** **the** **brilliant** **unfolding** **of** **classical** **Greek** **culture**.

count: 224

# Official 50-Passage 02 The Achievement of Brazilian Independence

**In** contrast **to** **the** **political** anarchy, economic dislocation, **and** military destruction **in** **Spanish** **America**, Brazil’s **drive** **toward** **independence** **from** Portugal proceeded **as** **a** relatively bloodless transition **between** 1808 **and** 1822. **The** **idea** **of** Brazilian **independence** **first** **arose** **in** **the** **late** eighteenth **century** **as** **a** Brazilian reaction **to** **the** Portuguese **policy** **of** tightening **political** **and** economic **control** **over** **the** colony **in** **the** **interests** **of** **the** **mother** **country**. **The** **first** significant conspiracy **against** Portuguese **rule** **was** organized **from** 1788–1799 **in** **the** **province** **of** Minas Gerais, **where** **rigid** governmental **control** **over** **the** **production** **and** **prices** **of** **gold** **and** **diamonds**, **as** **well** **as** **heavy** **taxes**, **caused** **much** discontent. **But** **this** conspiracy **never** **went** **beyond** **the** **stage** **of** **discussion** **and** **was** **easily** **discovered** **and** crushed. **Other** conspiracies **in** **the** **late** eighteenth **century** **as** **well** **as** **a** **brief** revolt **in** 1817 **reflected** **the** **influence** **of** republican **ideas** **over** **sections** **of** **the** elite **and** **even** **the** lower strata **of** **urban** **society**. **All** **proved** abortive **or** **were** **soon** crushed. **Were** **it** **not** **for** an **accident** **of** **European** **history**, **the** **independence** **of** Brazil **might** **have** **been** **long** **delayed**.

**The** **French** invasion **of** Portugal **in** 1807 **followed** **by** **the** **flight** **of** **the** Portuguese **court** (sovereign **and** **government** **officers**) **to** Rio de Janeiro **brought** **large** **benefits** **to** Brazil. **Indeed**, **the** transfer **of** **the** **court** **in** **effect** signified **achievement** **of** Brazilian **independence**. **The** Portuguese prince **and** **future** **King** João VI **opened** Brazil’s **ports** **to** **the** **trade** **of** **friendly** **nations**, **permitted** **the** **rise** **of** **local** **industries**, **and** **founded** **the** **Bank** **of** Brazil. **In** 1815 **he** elevated Brazil **to** **the** **legal** **status** **of** **a** **kingdom** coequal **with** Portugal. **In** **one** **sense**, **however**, Brazil’s **new** **status** signified **the** substitution **of** **one** dependence **for** **another**. **Freed** **from** Portuguese **control**, Brazil **came** **under** **the** economic dominance **of** **England**, **which** **obtained** **major** tariff concessions **and** **other** **privileges** **by** **the** Strangford Treaty **of** 1810 **between** Portugal **and** **Great** **Britain**. **The** treaty **provided** **for** **the** importation **of** **British** manufactures **into** Brazil **and** **the** **export** **of** Brazilian **agricultural** **produce** **to** **Great** **Britain**. **One** **result** **was** an influx **of** **cheap** **machine**-**made** **goods** **that** swamped **the** handicrafts **industry** **of** **the** **country**.

Brazilian elites **took** **satisfaction** **in** Brazil’s **new** **role** **and** **the** **growth** **of** educational, cultural, **and** economic opportunities **for** **their** **class**. **But** **the** **feeling** **was** **mixed** **with** resentment **toward** **the** **thousands** **of** Portuguese courtiers (**officials**) **and** hangers-**on** **who** **came** **with** **the** **court** **and** **who** **competed** **with** Brazilians **for** **jobs** **and** favors. **Thus**, **the** **change** **in** **the** **status** **of** Brazil **sharpened** **the** **conflict** **between** Portuguese elites **born** **in** Brazil **and** elites **born** **in** Portugal **and** loyal **to** **the** Portuguese crown.

**The** **event** **that** precipitated **the** **break** **with** **the** **mother** **country** **was** **the** **revolution** **of** 1820 **in** Portugal. **The** Portuguese revolutionaries framed **a** liberal **constitution** **for** **the** **kingdom**, **but** **they** **were** **conservative** **or** reactionary **in** **relation** **to** Brazil. **They** **demanded** **the** **immediate** **return** **of** **King** João **to** Lisbon, an **end** **to** **the** **system** **of** dual monarchy **that** **he** **had** devised, **and** **the** restoration **of** **the** Portuguese commercial monopoly. Timid **and** vacillating, **King** João **did** **not** **know** **which** **way** **to** **turn**. **Under** **the** **pressure** **of** **his** courtiers, **who** **hungered** **to** **return** **to** Portugal **and** **their** **lost** estates, **he** finally **approved** **the** **new** **constitution** **and** **sailed** **for** Portugal. **He** **left** **behind** **him**, **however**, **his** **son** **and** heir, Pedro, **and** **in** **a** **private** **letter** **advised** **him** **that** **in** **the** **event** **the** Brazilians **should** **demand** **independence**, **he** **should** **assume** leadership **of** **the** **movement** **and** **set** **the** crown **of** Brazil **on** **his** **head**.

**Soon** **it** **became** **clear** **that** **the** Portuguese parliament **intended** **to** **set** **the** **clock** **back** **by** abrogating **all** **the** **liberties** **and** concessions **won** **by** Brazil **since** 1808. **One** **of** **its** decrees **insisted** **on** **the** **immediate** **return** **of** Pedro **from** Brazil. **The** **pace** **of** **events** **moved** **more** rapidly **in** 1822. **On** **January** 9, **urged** **on** **by** Brazilian advisers **who** perceived **a** **golden** opportunity **to** **make** an orderly transition **to** **independence** **without** **the** intervention **of** **the** **masses**, Pedro **refused** an **order** **from** **the** parliament **to** **return** **to** Portugal, **saying** famously, “**I** **remain**.” **On** **September** 7, **regarded** **by** **all** Brazilians **as** **Independence** **Day**, **he** issued **the** **even** **more** **celebrated** proclamation, “**Independence** **or** **death**!” **In** **December** 1822, **having** **overcome** **slight** resistance **by** Portuguese **troops**, Dom Pedro **was** formally proclaimed constitutional **Emperor** **of** Brazil.

count: 223

# Official 43-Passage 01 El Nino

**The** **cold** Humboldt Current **of** **the Pacific Ocean** **Ocean** **flows** **toward** **the** equator **along** **the** **coasts** **of** Ecuador **and** Peru **in** **South** **America**. **When** **the** current **approaches** **the** equator, **the** westward-**flowing** **trade** **winds** **cause** nutrient-**rich** **cold** **water** **along** **the** **coast** **to** **rise** **from** deeper **depths** **to** **more** **shallow** **ones**. **This** upwelling **of** **water** **has** economic repercussions. **Fishing**, **especially** **for** anchovies, **is** **a** **major** **local** **industry**.

**Every** **year** **during** **the** **months** **of** **December** **and** **January**, **a** **weak**, **warm** countercurrent **replaces** **the** normally **cold** coastal **waters**. **Without** **the** upwelling **of** nutrients **from** **below** **to** **feed** **the** **fish**, **fishing** **comes** **to** **a** standstill. Fishers **in** **this** region **have** **known** **the** **phenomenon** **for** **hundreds** **of** **years**. **In** **fact**, **this** **is** **the** **time** **of** **year** **they** traditionally **set** **aside** **to** **tend** **to** **their** **equipment** **and** await **the** **return** **of** **cold** **water**. **The** residents **of** **the** region **have** **given** **this** **phenomenon** **the** **name** **of** El Niño, **which** **is** **Spanish** **for** “**the** **child**,” **because** **it** **occurs** **at** **about** **the** **time** **of** **the** **celebration** **of** **birth** **of** **the** Christ **child**.

**While** **the** **warm**-**water** countercurrent **usually** **lasts** **for** **two** **months** **or** **less**, **there** **are** occasions **when** **the** disruption **to** **the** **normal** **flow** **lasts** **for** **many** **months**. **In** **these** **situations**, **water** **temperatures** **are** **raised** **not** **just** **along** **the** **coast**, **but** **for** **thousands** **of** kilometers **offshore**. **Over** **the** **last** **few** **decades**, **the** **term** El Niño **has** **come** **to** **be** **used** **to** **describe** **these** exceptionally **strong** episodes **and** **not** **the** **annual** **event**. **During** **the** **past** 60 **years**, **at** **least** **ten** El Niños **have** **been** **observed**. **Not** **only** **do** El Niños **affect** **the** **temperature** **of** **the** equatorial **Pacific**, **but** **the** strongest **of** **them** impact global **weather**.

**The** **processes** **that** interact **to** **produce** an El Niño involve **conditions** **all** **across** **the** **Pacific**, **not** **just** **in** **the** **waters** **off** **South** **America**. **Over** 60 **years** **ago**, **Sir** Gilbert Walker, **a** **British** **scientist**, **discovered** **a** **connection** **between** **surface** **pressure** **readings** **at** **weather** **stations** **on** **the** **eastern** **and** **western** **sides** **of** **the** **Pacific**. **He** **noted** **that** **a** **rise** **in** atmospheric **pressure** **in** **the** **eastern** **Pacific** **is** **usually** **accompanied** **by** **a** **fall** **in** **pressure** **in** **the** **western** **Pacific** **and** **vice** versa. **He** **called** **this** seesaw **pattern** **the** **Southern** Oscillation. **It** **was** **later** realized **that** **there** **is** **a** **close** **link** **between** El Niño **and** **the** **Southern** Oscillation. **In** **fact**, **the** **link** **between** **the** **two** **is** **so** **great** **that** **they** **are** **often** **referred** **to** jointly **as** ENSO (El Niño–**Southern** Oscillation).

**During** **a** **typical** **year**, **the** **eastern** **Pacific** **has** **a** higher **pressure** **than** **the** **western** **Pacific** **does**. **This** **east**-**to**-**west** **pressure** gradient enhances **the** **trade** **winds** **over** **the** equatorial **waters**. **This** **results** **in** **a** **warm** **surface** current **that** **moves** **east** **to** **west** **at** **the** equator. **The** **western** **Pacific** **develops** **a** **thick**, **warm** layer **of** **water** **while** **the** **eastern** **Pacific** **has** **the** **cold** Humboldt Current enhanced **by** upwelling. **However**, **in** **other** **years** **the** **Southern** Oscillation, **for** **unknown** **reasons**, **swings** **in** **the** **opposite** **direction**, dramatically **changing** **the** **usual** **conditions** **described** **above**, **with** **pressure** **increasing** **in** **the** **western** **Pacific** **and** **decreasing** **in** **the** **eastern** **Pacific**. **This** **change** **in** **the** **pressure** gradient **causes** **the** **trade** **winds** **to** weaken **or**, **in** **some** **cases**, **to** reverse. **This** **then** **causes** **the** **warm** **water** **in** **the** **western** **Pacific** **to** **flow** eastward, **increasing** **sea**-**surface** **temperatures** **in** **the** **central** **and** **eastern** **Pacific**. **The** eastward shift **signals** **the** **beginning** **of** an El Niño.

**Scientists** **try** **to** **document** **as** **many** **past** El Niño **events** **as** **possible** **by** **piecing** **together** **bits** **of** historical **evidence**, **such** **as** **sea**-**surface** **temperature** **records**, **daily** observations **of** atmospheric **pressure** **and** **rainfall**, fisheries’ **records** **from** **South** **America**, **and** **the** **writings** **of** **Spanish** colonists **dating** **back** **to** **the** fifteenth **century**. **From** **such** historical **evidence** **we** **know** **that** El Niños **have** **occurred** **as** **far** **back** **as** **records** **go**. **It** **would** **seem** **that** **they** **are** **becoming** **more** **frequent**. **Records** indicate **that** **during** **the** **sixteenth** **century**, an El Niño **occurred** **on** **average** **every** **six** **years**. **Evidence** **gathered** **over** **the** **past** **few** **decades** indicates **that** El Niños **are** **now** **occurring** **on** **average** **a** **little** **over** **every** **two** **years**. **Even** **more** **alarming** **is** **the** **fact** **that** **they** **appear** **to** **be** **getting** stronger. **The** 1997–1998 El Niño **brought** copious **and** **damaging** **rainfall** **to** **the** **southern** **United** **States**, **from** California **to** Florida. Snowstorms **in** **the** **northeast** portion **of** **the** **United** **States** **were** **more** **frequent** **and** intense **than** **in** **most** **years**.

count: 223

# Official 14-Passage 01 Children and Advertising

**Young** **children** **are** **trusting** **of** commercial **advertisements** **in** **the** **media**, **and** advertisers **have** **sometimes** **been** **accused** **of** **taking** **advantage** **of** **this** **trusting** outlook. **The** **Independent** **Television** Commission, regulator **of** **television** **advertising** **in** **the** **United** **Kingdom**, **has** criticized advertisers **for** “misleadingness”—**creating** **a** **wrong** **impression** **either** intentionally **or** unintentionally—**in** an **effort** **to** **control** advertisers’ **use** **of** **techniques** **that** **make** **it** **difficult** **for** **children** **to** **judge** **the** **true** **size**, **action**, **performance**, **or** **construction** **of** **a** **toy**.

**General** **concern** **about** misleading tactics **that** advertisers **employ** **is** centered **on** **the** **use** **of** exaggeration. Consumer **protection** **groups** **and** **parents** **believe** **that** **children** **are** largely **ill**-**equipped** **to** recognize **such** **techniques** **and** **that** **often** exaggeration **is** **used** **at** **the** **expense** **of** **product** **information**. Claims **such** **as** “**the** **best**” **or** “**better** **than**” **can** **be** **subjective** **and** misleading; **even** **adults** may **be** unsure **as** **to** **their** **meaning**. **They** **represent** **the** advertiser’s **opinions** **about** **the** **qualities** **of** **their** **products** **or** **brand** **and**, **as** **a** **consequence**, **are** **difficult** **to** verify. Advertisers **sometimes** offset **or** counterbalance an exaggerated claim **with** **a** disclaimer—**a** **qualification** **or** **condition** **on** **the** claim. **For** **example**, **the** claim **that** **breakfast** cereal **has** **a** **health** **benefit** may **be** **accompanied** **by** **the** disclaimer “**when** **part** **of** **a** nutritionally **balanced** **breakfast**.” **However**, **research** **has** **shown** **that** **children** **often** **have** **difficulty** **understanding** disclaimers: **children** may interpret **the** **phrase** “**when** **part** **of** **a** nutritionally **balanced** **breakfast**” **to** **mean** **that** **the** cereal **is** **required** **as** **a** **necessary** **part** **of** **a** **balanced** **breakfast**. **The** **author** George Comstock **suggested** **that** **less** **than** **a** **quarter** **of** **children** **between** **the** **ages** **of** **six** **and** **eight** **years** **old** **understood** **standard** disclaimers **used** **in** **many** **toy** **advertisements** **and** **that** disclaimers **are** **more** readily comprehended **when** **presented** **in** **both** audio **and** **visual** **formats**. Nevertheless, disclaimers **are** mainly **presented** **in** audio **format** **only**.

**Fantasy** **is** **one** **of** **the** **more** **common** **techniques** **in** **advertising** **that** **could** **possibly** mislead **a** **young** **audience**. **Child**-oriented **advertisements** **are** **more** **likely** **to** **include** **magic** **and** **fantasy** **than** **advertisements** **aimed** **at** **adults**. **In** **a** **content** **analysis** **of** **Canadian** **television**, **the** **author** Stephen Kline **observed** **that** **nearly** **all** commercials **for** **character** **toys** featured **fantasy** **play**. **Children** **have** **strong** imaginations **and** **the** **use** **of** **fantasy** **brings** **their** **ideas** **to** **life**, **but** **children** may **not** **be** adept **enough** **to** realize **that** **what** **they** **are** **viewing** **is** unreal. **Fantasy** **situations** **and** settings **are** frequently **used** **to** **attract** **children**’s **attention**, particularly **in** **food** **advertising**. **Advertisements** **for** **breakfast** cereals **have**, **for** **many** **years**, **been** **found** **to** **be** **especially** **fond** **of** **fantasy** **techniques**, **with** **almost** **nine** **out** **of** **ten** **including** **such** **content**. Generally, **there** **is** uncertainty **as** **to** **whether** **very** **young** **children** **can** **distinguish** **between** **fantasy** **and** **reality** **in** **advertising**. **Certainly**, rational **appeals** **in** **advertising** **aimed** **at** **children** **are** **limited**, **as** **most** **advertisements** **use** emotional **and** indirect **appeals** **to** psychological **states** **or** **associations**.

**The** **use** **of** celebrities **such** **as** **singers** **and** **movie** **stars** **is** **common** **in** **advertising**. **The** **intention** **is** **for** **the** positively perceived attributes **of** **the** celebrity **to** **be** transferred **to** **the** **advertised** **product** **and** **for** **the** **two** **to** **become** automatically **linked** **in** **the** **audience**’s **mind**. **In** **children**’s **advertising**, **the** “celebrities” **are** **often** animated **figures** **from** **popular** **cartoons**. **In** **the** **recent** **past**, **the** **role** **of** celebrities **in** **advertising** **to** **children** **has** **often** **been** conflated **with** **the** **concept** **of** **host** **selling**. **Host** **selling** involves blending **advertisements** **with** **regular** **programming** **in** **a** **way** **that** **makes** **it** **difficult** **to** **distinguish** **one** **from** **the** **other**. **Host** **selling** **occurs**, **for** **example**, **when** **a** **children**’s **show** **about** **a** **cartoon** **lion** **contains** an **ad** **in** **which** **the** **same** **lion** **promotes** **a** **breakfast** cereal. **The** psychologist Dale Kunkel **showed** **that** **the** **practice** **of** **host** **selling** **reduced** **children**’s **ability** **to** **distinguish** **between** **advertising** **and** program **material**. **It** **was** **also** **found** **that** older **children** **responded** **more** positively **to** **products** **in** **host** **selling** **advertisements**.

**Regarding** **the** **appearance** **of** celebrities **in** **advertisements** **that** **do** **not** involve **host** **selling**, **the** **evidence** **is** **mixed**. Researcher Charles Atkin **found** **that** **children** **believe** **that** **the** **characters** **used** **to** **advertise** **breakfast** cereals **are** knowledgeable **about** cereals, **and** **children** **accept** **such** **characters** **as** credible sources **of** nutritional **information**. **This** **finding** **was** **even** **more** **marked** **for** **heavy** **viewers** **of** **television**. **In** **addition**, **children** **feel** validated **in** **their** **choice** **of** **a** **product** **when** **a** celebrity endorses **that** **product**. **A** **study** **of** **children** **in** **Hong Kong**, **however**, **found** **that** **the** presence **of** celebrities **in** **advertisements** **could** negatively **affect** **the** **children**’s perceptions **of** **a** **product** **if** **the** **children** **did** **not** **like** **the** celebrity **in** **question**.

count: 222

# Official 01-Passage 01 Groundwater

Groundwater **is** **the** **word** **used** **to** **describe** **water** **that** saturates **the** **ground**, **filling** **all** **the** **available** **spaces**. **By** **far** **the** **most** **abundant** **type** **of** groundwater **is** meteoric **water**; **this** **is** **the** groundwater **that** **circulates** **as** **part** **of** **the** **water** **cycle**. **Ordinary** meteoric **water** **is** **water** **that** **has** soaked **into** **the** **ground** **from** **the** **surface**, **from** precipitation (**rain** **and** **snow**) **and** **from** **lakes** **and** **streams**. **There** **it** **remains**, **sometimes** **for** **long** **periods**, **before** emerging **at** **the** **surface** **again**. **At** **first** **thought** **it** **seems** incredible **that** **there** **can** **be** **enough** **space** **in** **the** “**solid**” **ground** underfoot **to** **hold** **all** **this** **water**.

**The** **necessary** **space** **is** **there**, **however**, **in** **many** **forms**. **The** commonest **spaces** **are** **those** **among** **the** particles—**sand** **grains** **and** **tiny** pebbles—**of** **loose**, unconsolidated **sand** **and** gravel. **Beds** **of** **this** **material**, **out** **of** **sight** **beneath** **the** **soil**, **are** **common**. **They** **are** **found** **wherever** **fast** **rivers** **carrying** **loads** **of** coarse sediment [1] **once** **flowed**. **For** **example**, **as** **the** **great** **ice** **sheets** **that** **covered** **North** **America** **during** **the** **last** **ice** **age** steadily melted **away**, **huge** volumes **of** **water** **flowed** **from** **them**. **The** **water** **was** **always** laden **with** pebbles, gravel, **and** **sand**, **known** **as** glacial outwash, **that** **was** **deposited** **as** **the** **flow** **slowed** **down**.

**The** **same** **thing** **happens** **to** **this** **day**, **though** **on** **a** smaller scale, **wherever** **a** sediment-laden **river** **or** **stream** emerges **from** **a** **mountain** **valley** **onto** relatively **flat** **land**, **dropping** **its** **load** **as** **the** current **slows**: **the** **water** **usually** **spreads** **out** fanwise, **depositing** **the** sediment **in** **the** **form** **of** **a** **smooth**, **fan**-**shaped** slope. Sediments **are** **also** **dropped** **where** **a** **river** **slows** **on** **entering** **a** **lake** **or** **the** **sea**; **the** **deposited** sediments **are** **on** **a** **lake** **floor** **or** **the** seafloor **at** **first**, **but** **will** **be** located **inland** **at** **some** **future** **date**, **when** **the** **sea** **level** **falls** **or** **the** **land** **rises**; **such** **beds** **are** **sometimes** **thousands** **of** meters **thick**.

**In** lowland **country** **almost** **any** **spot** **on** **the** **ground** may overlie **what** **was** **once** **the** **bed** **of** **a** **river** **that** **has** **since** **become** **buried** **by** **soil**; **if** **they** **are** **now** **below** **the** **water**’s **upper** **surface** (**the** **water** **table**), **the** gravels **and** **sands** **of** **the** **former** riverbed, **and** **its** sandbars, **will** **be** saturated **with** groundwater.

**So** **much** **for** unconsolidated sediments. Consolidated (**or** cemented) sediments, **too**, **contain** **millions** **of** **minute** **water**-**holding** pores. **This** **is** **because** **the** gaps **among** **the** original **grains** **are** **often** **not** **totally** **plugged** **with** cementing **chemicals**; **also**, **parts** **of** **the** original **grains** may **become** dissolved **by** percolating groundwater, **either** **while** consolidation **is** **taking** **place** **or** **at** **any** **time** **afterwards**. **The** **result** **is** **that** sandstone, **for** **example**, **can** **be** **as** porous **as** **the** **loose** **sand** **from** **which** **it** **was** **formed**.

**Thus** **a** proportion **of** **the** **total** volume **of** **any** sediment, **loose** **or** cemented, **consists** **of** **empty** **space**. **Most** crystalline **rocks** **are** **much** **more** **solid**; **a** **common** exception **is** basalt, **a** **form** **of** solidified volcanic lava, **which** **is** **sometimes** **full** **of** **tiny** bubbles **that** **make** **it** **very** porous.

**The** proportion **of** **empty** **space** **in** **a** **rock** **is** **known** **as** **its** porosity. **But** **note** **that** porosity **is** **not** **the** **same** **as** permeability, **which** **measures** **the** **ease** **with** **which** **water** **can** **flow** **through** **a** **material**; **this** **depends** **on** **the** **sizes** **of** **the** individual cavities **and** **the** crevices **linking** **them**.

**Much** **of** **the** **water** **in** **a** sample **of** **water**-saturated sediment **or** **rock** **will** drain **from** **it** **if** **the** sample **is** **put** **in** **a** **suitable** **dry** **place**. **But** **some** **will** **remain**, clinging **to** **all** **solid** **surfaces**. **It** **is** **held** **there** **by** **the** **force** **of** **surface** **tension** [2] **without** **which** **water** **would** drain instantly **from** **any** **wet** **surface**, **leaving** **it** **totally** **dry**. **The** **total** volume **of** **water** **in** **the** saturated sample must **therefore** **be** **thought** **of** **as** **consisting** **of** **water** **that** **can**, **and** **water** **that** cannot, **in** **away**.

**The** **relative** **amount** **of** **these** **two** **kinds** **of** **water** varies greatly **from** **one** **kind** **of** **rock** **or** sediment **to** **another**, **even** **though** **their** porosities may **be** **the** **same**. **What** **happens** **depends** **on** pore **size**. **If** **the** pores **are** **large**, **the** **water** **in** **them** **will** **exist** **as** **drops** **too** **heavy** **for** **surface** **tension** **to** **hold**, **and** **it** **will** drain **away**; **but** **if** **the** pores **are** **small** **enough**, **the** **water** **in** **them** **will** **exist** **as** **thin** **films**, **too** **light** **to** **overcome** **the** **force** **of** **surface** **tension** **holding** **them** **in** **place**: **then** **the** **water** **will** **be** **firmly** **held**.

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 sediment: **loose** particles **of** **minerals**

**surface** **tension**: **a** property **of** **water** **that** **causes** **it** **to** adhere **to** **itself** **and** **to** **certain** **solids**

count: 222

# Official 48-Passage 01 Chinese Population Growth

**Increases** **in** **population** **have** **usually** **been** **accompanied** (**indeed** facilitated) **by** an **increase** **in** **trade**. **In** **the** **Western** **experience**, commerce **provided** **the** **conditions** **that** **allowed** industrialization **to** **get** **started**, **which** **in** **turn** **led** **to** **growth** **in** **science**, **technology**, **industry**, **transport**, **communications**, **social** **change**, **and** **the** **like** **that** **we** **group** **under** **the** **broad** **term** **of** “**development**.” **However**, **the** massive **increase** **in** **population** **that** **in** **Europe** **was** **at** **first** attributed **to** industrialization **starting** **in** **the** eighteenth **century** **occurred** **also** **and** **at** **the** **same** **period** **in** **China**, **even** **though** **there** **was** **no** comparable industrialization.

**It** **is** estimated **that** **the** **Chinese** **population** **by** 1600 **was** **close** **to** 150 **million**. **The** transition **between** **the** Ming **and** Qing dynasties (**the** seventeenth **century**) may **have** **seen** **a** **decline**, **but** **from** 1741 **to** 1851 **the** **annual** **figures** **rose** steadily **and** spectacularly, **perhaps** **beginning** **with** 143 **million** **and** **ending** **with** 432 **million**. **If** **we** **accept** **these** **totals**, **we** **are** confronted **with** **a** **situation** **in** **which** **the** **Chinese** **population** **doubled** **in** **the** 50 **years** **from** 1790 **to** 1840. **If**, **with** greater **caution**, **we** **assume** lower **totals** **in** **the** **early** eighteenth **century** **and** **only** 400 **million** **in** 1850, **we** **still** **face** **a** startling **fact**: **something** **like** **a** **doubling** **of** **the** **vast** **Chinese** **population** **in** **the** **century** **before** **Western** contact, **foreign** **trade**, **and** industrialization **could** **have** **had** **much** **effect**.

**To** **explain** **this** **sudden** **increase** **we** cannot **point** **to** factors **constant** **in** **Chinese** **society** **but** must **find** **conditions** **or** **a** combination **of** factors **that** **were** newly effective **in** **this** **period**. **Among** **these** **is** **the** **almost** **complete** internal **peace** maintained **under** Manchu **rule** **during** **the** eighteenth **century**. **There** **was** **also** an **increase** **in** **foreign** **trade** **through** Guangzhou (**southern** **China**) **and** **some** improvement **of** transportation **within** **the** **empire**. **Control** **of** **disease**, **like** **the** **checking** **of** smallpox **by** variolation may **have** **been** **important**. **But** **of** **most** critical **importance** **was** **the** **food** **supply**.

Confronted **with** **a** multitude **of** unreliable **figures**, economists **have** **compared** **the** **population** **records** **with** **the** aggregate **data** **for** cultivated **land** **area** **and** **grain** **production** **in** **the** **six** **centuries** **since** 1368. **Assuming** **that** **China**’s **population** **in** 1400 **was** **about** 80 **million**, **the** economist Dwight Perkins **concludes** **that** **its** **growth** **to** 700 **million** **or** **more** **in** **the** 1960s **was** **made** **possible** **by** **a** **steady** **increase** **in** **the** **grain** **supply**, **which** evidently **grew** **five** **or** **six** **times** **between** 1400 **and** 1800 **and** **rose** **another** 50 **percent** **between** 1800 **and** 1965. **This** **increase** **of** **food** **supply** **was** **due** **perhaps** **half** **to** **the** **increase** **of** cultivated **area**, particularly **by** migration **and** **settlement** **in** **the** **central** **and** **western** **provinces**, **and** **half** **to** greater productivity—**the** **farmers**’ **success** **in** **raising** **more** **crops** **per** **unit** **of** **land**.

**This** technological **advance** **took** **many** **forms**: **one** **was** **the** continual **introduction** **from** **the** **south** **of** earlier-**ripening** **varieties** **of** **rice**, **which** **made** **possible** **double**-**cropping** (**the** **production** **of** **two** **harvests** **per** **year** **from** **one** **field**). **New** **crops** **such** **as** **corn** (maize) **and** **sweet** **potatoes** **as** **well** **as** peanuts **and** **tobacco** **were** **introduced** **from** **the** Americas. **Corn**, **for** instance, **can** **be** **grown** **on** **the** **dry** **soil** **and** marginal **hill** **land** **of** **North** **China**, **where** **it** **is** **used** **for** **food**, **fuel**, **and** fodder **and** **provides** **something** **like** **one**-**seventh** **of** **the** **food** energy **available** **in** **the** **area**. **The** **sweet** **potato**, **growing** **in** sandy **soil** **and** **providing** **more** **food** energy **per** **unit** **of** **land** **than** **other** **crops**, **became** **the** **main** **food** **of** **the** **poor** **in** **much** **of** **the** **South** **China** **rice** **area**.

Productivity **in** **agriculture** **was** **also** **improved** **by** **capital** investments, **first** **of** **all** **in** **irrigation**. **From** 1400 **to** 1900 **the** **total** **of** **irrigated** **land** **seems** **to** **have** **increased** **almost** **three** **times**. **There** **was** **also** **a** **gain** **in** **farm** **tools**, **draft** **animals**, **and** fertilizer, **to** **say** **nothing** **of** **the** **population** **growth** **itself**, **which** **increased** **half** **again** **as** **fast** **as** cultivated **land** **area** **and** **so** **increased** **the** ratio **of** **human** **hands** **available** **per** **unit** **of** **land**. **Thus** **the** **rising** **population** **was** **fed** **by** **a** **more** intensive **agriculture**, **applying** **more** labor **and** fertilizer **to** **the** **land**.

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 variolation: deliberate infection **with** smallpox **in** **order** **to** immunize **a** **person** **against** **this** **disease**

count: 221

# Official 21-Passage 02 The Origins of Agriculture

**How** **did** **it** **come** **about** **that** **farming** **developed** independently **in** **a** **number** **of** **world** centers (**the** **Southeast** **Asian** **mainland**, **Southwest** **Asia**, **Central** **America**, lowland **and** highland **South** **America**, **and** equatorial **Africa**) **at** **more** **or** **less** **the** **same** **time**? **Agriculture** **developed** slowly **among** **populations** **that** **had** an extensive **knowledge** **of** **plants** **and** **animals**. **Changing** **from** **hunting** **and** **gathering** **to** **agriculture** **had** **no** **immediate** **advantages**. **To** **start** **with**, **it** **forced** **the** **population** **to** **abandon** **the** nomad’s **life** **and** **become** sedentary, **to** **develop** **methods** **of** **storage** **and**, **often**, **systems** **of** **irrigation**. **While** **hunter**-gatherers **always** **had** **the** option **of** **moving** elsewhere **when** **the** resources **were** exhausted, **this** **became** **more** **difficult** **with** **farming**. Furthermore, **as** **the** archaeological **record** **shows**, **the** **state** **of** **health** **of** agriculturalists **was** **worse** **than** **that** **of** **their** **contemporary** **hunter**-gatherers.

Traditionally, **it** **was** **believed** **that** **the** transition **to** **agriculture** **was** **the** **result** **of** **a** **worldwide** **population** crisis. **It** **was** **argued** **that** **once** **hunter**-gatherers **had** occupied **the** **whole** **world**, **the** **population** **started** **to** **grow** **everywhere** **and** **food** **became** scarce; **agriculture** **would** **have** **been** **a** solution **to** **this** **problem**. **We** **know**, **however**, **that** **contemporary** **hunter**-gatherer **societies** **control** **their** **population** **in** **a** **variety** **of** **ways**. **The** **idea** **of** **a** **world** **population** crisis **is** **therefore** unlikely, **although** **population** **pressure** **might** **have** **arisen** **in** **some** **areas**.

Climatic **changes** **at** **the** **end** **of** **the** glacial **period** 13,000 **years** **ago** **have** **been** proposed **to** **account** **for** **the** emergence **of** **farming**. **The** **temperature** **increased** dramatically **in** **a** **short** **period** **of** **time** (**years** **rather** **than** **centuries**), **allowing** **for** **a** **growth** **of** **the** **hunting**-**gathering** **population** **due** **to** **the** abundance **of** resources. **There** **were**, **however**, fluctuations **in** **the** climatic **conditions**, **with** **the** **consequences** **that** **wet** **conditions** **were** **followed** **by** **dry** **ones**, **so** **that** **the** availability **of** **plants** **and** **animals** oscillated brusquely.

**It** **would** **appear** **that** **the** instability **of** **the** climatic **conditions** **led** **populations** **that** **had** originally **been** nomadic **to** **settle** **down** **and** **develop** **a** sedentary **style** **of** **life**, **which** **led** **in** **turn** **to** **population** **growth** **and** **to** **the** **need** **to** **increase** **the** **amount** **of** **food** **available**. **Farming** originated **in** **these** **conditions**. **Later** **on**, **it** **became** **very** **difficult** **to** **change** **because** **of** **the** significant expansion **of** **these** **populations**. **It** **could** **be** **argued**, **however**, **that** **these** **conditions** **are** **not** sufficient **to** **explain** **the** **origins** **of** **agriculture**. **Earth** **had** **experienced** previous **periods** **of** climatic **change**, **and** **yet** **agriculture** **had** **not** **been** **developed**.

**It** **is** archaeologist Steven Mithen’s thesis, brilliantly **developed** **in** **his** **book** **The** Prehistory **of** **the** **Mind** (1996), **that** **approximately** 40,000 **years** **ago** **the** **human** **mind** **developed** cognitive fluidity, **that** **is**, **the** integration **of** **the** specializations **of** **the** **mind**: **technical**, **natural** **history** (geared **to** **understanding** **the** behavior **and** distribution **of** **natural** resources), **social** **intelligence**, **and** **the** linguistic capacity. Cognitive fluidity **explains** **the** **appearance** **of** **art**, **religion**, **and** sophisticated **speech**. **Once** **humans** **possessed** **such** **a** **mind**, **they** **were** **able** **to** **find** an imaginative solution **to** **a** **situation** **of** **severe** economic crisis **such** **as** **the** **farming** **dilemma** **described** earlier. Mithen proposes **the** **existence** **of** **four** **mental** elements **to** **account** **for** **the** emergence **of** **farming**: (1) **the** **ability** **to** **develop** **tools** **that** **could** **be** **used** intensively **to** **harvest** **and** **process** **plant** resources; (2) **the** **tendency** **to** **use** **plants** **and** **animals** **as** **the** **medium** **to** **acquire** **social** prestige **and** **power**; (3) **the** **tendency** **to** **develop** “**social** **relationships**” **with** **animals** structurally **similar** **to** **those** **developed** **with** **people**—specifically, **the** **ability** **to** **think** **of** **animals** **as** **people** (anthropomorphism) **and** **of** **people** **as** **animals** (totemism); **and** (4) **the** **tendency** **to** manipulate **plants** **and** **animals**.

**The** **fact** **that** **some** **societies** domesticated **animals** **and** **plants**, **discovered** **the** **use** **of** **metal** **tools**, **became** literate, **and** **developed** **a** **state** **should** **not** **make** us **forget** **that** **others** **developed** pastoralism **or** horticulture (**vegetable** **gardening**) **but** **remained** illiterate **and** **at** **low** **levels** **of** productivity; **a** **few** **entered** **the** **modern** **period** **as** **hunting** **and** **gathering** **societies**. **It** **is** anthropologically **important** **to** inquire **into** **the** **conditions** **that** **made** **some** **societies** **adopt** **agriculture** **while** **others** **remained** **hunter**-gatherers **or** horticulturalists. **However**, **it** **should** **be** **kept** **in** **mind** **that** **many** **societies** **that** **knew** **of** **agriculture** **more** **or** **less** consciously **avoided** **it**. **Whether** Mithen’s **explanation** **is** satisfactory **is** **open** **to** contention, **and** **some** **authors** **have** recently emphasized **the** **importance** **of** **other** factors.

count: 219

# Official 04-Passage 02 Cave Art in Europe

**The** earliest **discovered** traces **of** **art** **are** beads **and** carvings, **and** **then** **paintings**, **from** sites **dating** **back** **to** **the** **Upper** Paleolithic **period**. **We** **might** **expect** **that** **early** artistic **efforts** **would** **be** crude, **but** **the** **cave** **paintings** **of** **Spain** **and** **southern** **France** **show** **a** **marked** **degree** **of** **skill**. **So** **do** **the** naturalistic **paintings** **on** slabs **of** **stone** excavated **in** **southern** **Africa**. **Some** **of** **those** slabs **appear** **to** **have** **been** **painted** **as** **much** **as** 28,000 **years** **ago**, **which** **suggests** **that** **painting** **in** **Africa** **is** **as** **old** **as** **painting** **in** **Europe**. **But** **painting** may **be** **even** older **than** **that**. **The** **early** Australians may **have** **painted** **on** **the** **walls** **of** **rock** **shelters** **and** cliff **faces** **at** **least** 30,000 **years** **ago**, **and** **maybe** **as** **much** **as** 60,000 **years** **ago**.

**The** researchers Peter Ucko **and** Andrée Rosenfeld identified **three** principal locations **of** **paintings** **in** **the** **caves** **of** **western** **Europe**: (1) **in** obviously inhabited **rock** **shelters** **and** **cave** **entrances**; (2) **in** **galleries** **immediately** **off** **the** inhabited **areas** **of** **caves**; **and** (3) **in** **the** inner **reaches** **of** **caves**, **whose** **difficulty** **of** **access** **has** **been** interpreted **by** **some** **as** **a** **sign** **that** magical-**religious** **activities** **were** **performed** **there**.

**The** **subjects** **of** **the** **paintings** **are** mostly **animals**. **The** **paintings** **rest** **on** **bare** **walls**, **with** **no** backdrops **or** environmental trappings. **Perhaps**, **like** **many** **contemporary** **peoples**, **Upper** Paleolithic **men** **and** **women** **believed** **that** **the** **drawing** **of** **a** **human** image **could** **cause** **death** **or** **injury**, **and** **if** **that** **were** **indeed** **their** **belief**, **it** **might** **explain** **why** **human** **figures** **are** rarely depicted **in** **cave** **art**. **Another** **explanation** **for** **the** **focus** **on** **animals** **might** **be** **that** **these** **people** **sought** **to** **improve** **their** **luck** **at** **hunting**. **This** **theory** **is** **suggested** **by** **evidence** **of** **chips** **in** **the** **painted** **figures**, **perhaps** **made** **by** **spears** **thrown** **at** **the** **drawings**. **But** **if** **improving** **their** **hunting** **luck** **was** **the** **chief** **motivation** **for** **the** **paintings**, **it** **is** **difficult** **to** **explain** **why** **only** **a** **few** **show** **signs** **of** **having** **been** **speared**. **Perhaps** **the** **paintings** **were** **inspired** **by** **the** **need** **to** **increase** **the** **supply** **of** **animals**. **Cave** **art** **seems** **to** **have** **reached** **a** peak **toward** **the** **end** **of** **the** **Upper** Paleolithic **period**, **when** **the** herds **of** **game** **were** **decreasing**.

**The** **particular** symbolic **significance** **of** **the** **cave** **paintings** **in** southwestern **France** **is** **more** explicitly revealed, **perhaps**, **by** **the** **results** **of** **a** **study** **conducted** **by** researchers Patricia **Rice** **and** Ann Paterson. **The** **data** **they** **present** **suggest** **that** **the** **animals** portrayed **in** **the** **cave** **paintings** **were** mostly **the** **ones** **that** **the** **painters** **preferred** **for** **meat** **and** **for** **materials** **such** **as** **hides**. **For** **example**, **wild** **cattle** (bovines) **and** **horses** **are** portrayed **more** **often** **than** **we** **would** **expect** **by** **chance**, **probably** **because** **they** **were** larger **and** heavier (meatier) **than** **other** **animals** **in** **the** **environment**. **In** **addition**, **the** **paintings** mostly portray **animals** **that** **the** **painters** may **have** **feared** **the** **most** **because** **of** **their** **size**, **speed**, **natural** weapons **such** **as** tusks **and** horns, **and** **the** unpredictability **of** **their** behavior. **That** **is**, mammoths, bovines, **and** **horses** **are** portrayed **more** **often** **than** **deer** **and** reindeer. **Thus**, **the** **paintings** **are** **consistent** **with** **the** **idea** **that** **the** **art** **is** **related** **to** **the** **importance** **of** **hunting** **in** **the** economy **of** **Upper** Paleolithic **people**. **Consistent** **with** **this** **idea**, **according to** **the** investigators, **is** **the** **fact** **that** **the** **art** **of** **the** cultural **period** **that** **followed** **the** **Upper** Paleolithic **also** **seems** **to** **reflect** **how** **people** **got** **their** **food**. **But** **in** **that** **period**, **when** **getting** **food** **no** longer **depended** **on** **hunting** **large** **game** **animals** (**because** **they** **were** **becoming** extinct), **the** **art** ceased **to** **focus** **on** portrayals **of** **animals**.

**Upper** Paleolithic **art** **was** **not** confined **to** **cave** **paintings**. **Many** shafts **of** **spears** **and** **similar** **objects** **were** **decorated** **with** **figures** **of** **animals**. **The** anthropologist Alexander Marshack **has** an **interesting** interpretation **of** **some** **of** **the** engravings **made** **during** **the** **Upper** Paleolithic. **He** **believes** **that** **as** **far** **back** **as** 30,000 B.C., **hunters** may **have** **used** **a** **system** **of** notation, engraved **on** **bone** **and** **stone**, **to** **mark** phases **of** **the** **Moon**. **If** **this** **is** **true**, **it** **would** **mean** **that** **Upper** Paleolithic **people** **were** capable **of** **complex** **thought** **and** **were** consciously **aware** **of** **their** **environment**. **In** **addition** **to** **other** artworks, figurines **representing** **the** **human** **female** **in** exaggerated **form** **have** **also** **been** **found** **at** **Upper** Paleolithic sites. **It** **has** **been** **suggested** **that** **these** figurines **were** an ideal **type** **or** an **expression** **of** **a** **desire** **for** fertility.

count: 219

# Official 37-Passage 02 Direct Species Translocation

**It** **is** **becoming** increasingly **common** **for** conservationists **to** **move** individual **animals** **or** **entire** species **from** **one** site **to** **another**. **This** may **be** **either** **to** establish **a** **new** **population** **where** **a** **population** **of** conspecifics (**animals** **or** **plants** **belonging** **to** **the** **same** species) **has** **become** extinct **or** **to** **add** individuals **to** an **existing** **population**. **The** **former** **is** **termed** reintroduction **and** **the** **latter** reinforcement. **In** **both** **cases**, **wild** individuals **are** captured **in** **one** location **and** translocated directly **to** **another**.

**Direct** translocation **has** **been** **used** **on** **a** **wide** **range** **of** **plants** **and** **animals** **and** **was** **carried** **out** **to** maintain **populations** **as** **a** source **of** **food** **long** **before** **conservation** **was** **a** **familiar** **term**. **The** **number** **of** translocations **carried** **out** **under** **the** banner **of** **conservation** **has** **increased** rapidly, **and** **this** **has** **led** **to** criticism **of** **the** **technique** **because** **of** **the** **lack** **of** evaluation **of** **its** efficacy **and** **because** **of** **its** **potential** **disadvantages**. **The** **nature** **of** translocation **ranges** **from** highly organized **and** **researched** **national** **or** **international** programs **to** **ad** hoc releases **of** **rescued** **animals** **by** **well**-intentioned **animal** lovers. **In** **a** fragmented landscape **where** **many** **populations** **and** habitats **are** isolated **from** **others**, translocations **can** **play** an effective **role** **in** **conservation** strategies; **they** **can** **increase** **the** **number** **of** **existing** **populations** **or** **increase** **the** **size**, genetic diversity, **and** demographic **balance** **of** **a** **small** **population**, consequently **increasing** **its** **chances** **of** **survival**.

Translocation **clearly** **has** **a** **role** **in** **the** recovery **of** species **that** **have** substantially **declined** **and** **is** **the** **most** **likely** **method** **by** **which** **many** sedentary species **can** **recover** **all** **or** **part** **of** **their** **former** **range**. **However**, **against** **this** **is** **the** **potential** **for** reinforcement translocations **to** **spread** **disease** **from** **one** **population** **to** **another** **or** **to** **introduce** deleterious **or** maladaptive genes **to** **a** **population**. Additionally, translocation **of** predators **or** **competitors** may **have** negative impacts **on** **other** species, **resulting** **in** an overall **loss** **of** diversity. **Last** **but** **not** **least** **of** **these** **considerations** **is** **the** **effort** **and** resources **required** **in** **this** **type** **of** **action**, **which** **need** **to** **be** justified **by** **evidence** **of** **the** **likely** **benefits**.

Despite **the** **large** **number** **of** translocations **that** **have** **taken** **place**, **there** **is** surprisingly **little** **evidence** **of** **the** efficacy **of** **such** **actions**. **This** **is** **partly** **because** **many** translocations **have** **not** **been** strictly **for** **conservation**; **neither** **have** **they** **been** **official** **nor** **legal**, **let** **alone** **scientific** **in** **their** **approach**. **Successful** translocations inevitably **get** **recorded** **and** **gain** **attention**, whereas **failures** may **never** **be** **recorded** **at** **all**. **This** **makes** appraisal **of** **the** **method** **very** **difficult**. **One** **key** **problem** **is** **a** definition **of** **success**. **Is** translocation **successful** **if** **the** individuals **survive** **the** **first** **week** **or** **a** **year**, **or** **do** **they** **need** **to** reproduce **for** **one** **or** **several** **generations**? **Whatever** **the** **answer**, **it** **is** **clear** **that** **a** **general** **framework** **is** **required** **to** ensure **that** **any** translocation **is** justified, **has** **a** realistic **chance** **of** **success**, **and** **will** **be** **properly** **monitored** **and** **evaluated** **for** **the** **benefit** **of** **future** **efforts**.

An **example** **of** **apparent** translocation **success** involves **the** threatened Seychelles warbler. **This** species **was** **once** confined **to** **Cousin** **Island**, **one** **of** **the** Seychelles **islands**, **and** **reduced** **to** 26 individuals. **Careful** habitat management **increased** **this** **number** **to** **over** 300 **birds**, **but** **the** **single** **population** **remained** vulnerable **to** **local** catastrophic **events**. **The** **decision** **was** **taken** **to** translocate individuals **to** **two** **nearby** **islands** **to** **reduce** **this** **risk**. **The** translocations **took** **place** **in** 1988 **and** 1990, **and** **both** **have** **resulted** **in** **healthy** breeding **populations**. **A** **successful** translocation **exercise** **also** **appears** **to** **have** **been** **achieved** **with** **red** howler **monkeys** **in** **French** Guiana. **A** howler **population** **was** translocated **from** **a** site **due** **to** **be** **flooded** **for** hydroelectric **power** **generation**. **The** release site **was** an **area** **where** **local** **hunting** **had** **reduced** **the** density **of** **the** resident howler **population**. Released **troops** **of** **monkeys** **were** **kept** **under** **visual** observation **and** **followed** **by** **radio** **tracking** **of** 16 **females**. **Although** **the** **troops** **appeared** **to** undergo **initial** **problems**, **causing** **them** **to** **split** **up**, **all** **the** **tracked** **females** **settled** **into** **normal** behavioral **patterns**.

**Unfortunately**, **the** **success** **stories** **are** **at** **least** **matched** **by** **accounts** **of** **failure**. **Reviewing** translocation **of** amphibians **and** reptiles, researchers C. Kenneth Dodd **and** Richard **A**. Siegel **concluded** **that** **most** **projects** **have** **not** demonstrated **success** **as** **conservation** **techniques** **and** **should** **not** **be** **advocated** **as** **though** **they** **were** acceptable management **and** mitigation **practices**.

count: 219

# Official 09-Passage 03 The Arrival of Plant Life in Hawaii

**When** **the** Hawaiian **Islands** emerged **from** **the** **sea** **as** **volcanoes**, **starting** **about** **five** **million** **years** **ago**, **they** **were** **far** **removed** **from** **other** landmasses. **Then**, **as** blazing **sunshine** alternated **with** drenching **rains**, **the** harsh, barren **surfaces** **of** **the** **black** **rocks** slowly **began** **to** soften. **Winds** **brought** **a** **variety** **of** **life**-**forms**.

Spores **light** **enough** **to** **float** **on** **the** breezes **were** **carried** **thousands** **of** **miles** **from** **more** **ancient** **lands** **and** **deposited** **at** **random** **across** **the** **bare** **mountain** flanks. **A** **few** **of** **these** spores **found** **a** toehold **on** **the** **dark**, **forbidding** **rocks** **and** **grew** **and** **began** **to** **work** **their** transformation **upon** **the** **land**. Lichens **were** **probably** **the** **first** **successful** flora. **These** **are** **not** **single** individual **plants**; **each** **one** **is** **a** symbiotic combination **of** an alga **and** **a** fungus. **The** algae capture **the** **Sun**’s energy **by** photosynthesis **and** **store** **it** **in** organic molecules. **The** fungi **absorb** moisture **and** **mineral** **salts** **from** **the** **rocks**, **passing** **these** **on** **in** **waste** **products** **that** nourish algae. **It** **is** significant **that** **the** earliest **living** **things** **that** **built** communities **on** **these** **islands** **are** **examples** **of** symbiosis, **a** **phenomenon** **that** **depends** **upon** **the** **close** cooperation **of** **two** **or** **more** **forms** **of** **life** **and** **a** **principle** **that** **is** **very** **important** **in** **island** communities.

Lichens **helped** **to** **speed** **the** decomposition **of** **the** **hard** **rock** **surfaces**, **preparing** **a** **soft** **bed** **of** **soil** **that** **was** abundantly **supplied** **with** **minerals** **that** **had** **been** **carried** **in** **the** molten **rock** **from** **the** bowels **of** **Earth**. **Now**, **other** **forms** **of** **life** **could** **take** **hold**: ferns **and** mosses (**two** **of** **the** **most** **ancient** **types** **of** **land** **plants**) **that** flourish **even** **in** **rock** crevices. **These** **plants** propagate **by** **producing** spores— **tiny** fertilized **cells** **that** **contain** **all** **the** **instructions** **for** **making** **a** **new** **plant**— **but** **the** spores **are** unprotected **by** **any** **outer** **coating** **and** **carry** **no** **supply** **of** nutrient. **Vast** **numbers** **of** **them** **fall** **on** **the** **ground** **beneath** **the** **mother** **plants**. **Sometimes** **they** **are** **carried** farther afield **by** **water** **or** **by** **wind**. **But** **only** **those** **few** spores **that** **settle** **down** **in** **very** favorable locations **can** **start** **new** **life**; **the** **vast** **majority** **fall** **on** barren **ground**. **By** **force** **of** sheer **numbers**, **however**, **the** mosses **and** ferns **reached** Hawaii, **survived**, **and** **multiplied**. **Some** species **developed** **great** **size**, **becoming** **tree** ferns **that** **even** **now** **grow** **in** **the** Hawaiian **forests**.

**Many** **millions** **of** **years** after ferns evolved (**but** **long** **before** **the** Hawaiian **Islands** **were** **born** **from** **the** **sea**), **another** **kind** **of** flora evolved **on** **Earth**: **the** **seed**-**bearing** **plants**. **This** **was** **a** **wonderful** biological **invention**. **The** **seed** **has** an **outer** **coating** **that** **surrounds** **the** genetic **material** **of** **the** **new** **plant**, **and** **inside** **this** **covering** **is** **a** **concentrated** **supply** **of** nutrients. **Thus**, **the** **seed**’s **chances** **of** **survival** **are** greatly enhanced **over** **those** **of** **the** naked spore. **One** **type** **of** **seed**-**bearing** **plant**, **the** angiosperm, **includes** **all** **forms** **of** blooming vegetation. **In** **the** angiosperm **the** **seeds** **are** wrapped **in** an additional layer **of** **covering**. **Some** **of** **these** **coats** **are** **hard**— **like** **the** shell **of** **a** **nut**— **for** **extra** **protection**. **Some** **are** **soft** **and** tempting, **like** **a** **peach** **or** **a** cherry. **In** **some** angiosperms **the** **seeds** **are** **equipped** **with** gossamer **wings**, **like** **the** dandelion **and** milkweed **seeds**. **These** **new** **characteristics** **offered** **better** **ways** **for** **the** **seeds** **to** **move** **to** **new** habitats. **They** **could** **travel** **through** **the** **air**, **float** **in** **water**, **and** **lie** dormant **for** **many** **months**.

**Plants** **with** **large**, buoyant **seeds**—**like** coconuts—drift **on** **ocean** currents **and** **are** **washed** **up** **on** **the** **shores**. Remarkably resistant **to** **the** vicissitudes **of** **ocean** **travel**, **they** **can** **survive** prolonged immersion **in** saltwater. **When** **they** **come** **to** **rest** **on** **warm** **beaches** **and** **the** **conditions** **are** favorable, **the** **seed** **coats** soften. Nourished **by** **their** **imported** **supply** **of** nutrients, **the** **young** **plants** **push** **out** **their** **roots** **and** establish **their** **place** **in** **the** **sun**.

**By** **means** **of** **these** **seeds**, **plants** **spread** **more** widely **to** **new** locations, **even** **to** isolated **islands** **like** **the** Hawaiian archipelago, **which** **lies** **more** **than** 2,000 **miles** **west** **of** California **and** 3,500 **miles** **east** **of** **Japan**. **The** **seeds** **of** **grasses**, **flowers**, **and** blooming **trees** **made** **the** **long** **trips** **to** **these** **islands**. (**Grasses** **are** **simple** **forms** **of** angiosperms **that** **bear** **their** encapsulated **seeds** **on** **long** stalks.) **In** **a** surprisingly **many** **of** **the** **land** **areas** **on** Hawaii **that** **had** **been** **bare**.

count: 219

# Official 06-Passage 02 William Smith

**In** 1769 **in** **a** **little** **town** **in** Oxfordshire, **England**, **a** **child** **with** **the** **very** **ordinary** **name** **of** William Smith **was** **born** **into** **the** **poor** **family** **of** **a** **village** blacksmith. **He** **received** rudimentary **village** **schooling**, **but** mostly **he** roamed **his** **uncle**’s **farm** **collecting** **the** fossils **that** **were** **so** **abundant** **in** **the** **rocks** **of** **the** Cotswold **hills**. **When** **he** **grew** older, William Smith **taught** **himself** surveying **from** **books** **he** **bought** **with** **his** **small** savings, **and** **at** **the** **age** **of** **eighteen** **he** **was** apprenticed **to** **a** surveyor **of** **the** **local** parish. **He** **then** proceeded **to** **teach** **himself** geology, **and** **when** **he** **was** **twenty**-**four**, **he** **went** **to** **work** **for** **the** **company** **that** **was** excavating **the** Somerset **Coal** **Canal** **in** **the** **south** **of** **England**.

**This** **was** **before** **the** **steam** locomotive, **and** **canal** **building** **was** **at** **its** **height**. **The** **companies** **building** **the** **canals** **to** **transport** **coal** **needed** surveyors **to** **help** **them** **find** **the** **coal** **deposits** **worth** **mining** **as** **well** **as** **to** **determine** **the** **best** **courses** **for** **the** **canals**. **This** **job** **gave** Smith an opportunity **to** **study** **the** **fresh** **rock** outcrops **created** **by** **the** newly **dug** **canal**. **He** **later** worked **on** **similar** **jobs** **across** **the** **length** **and** breadth **of** **England**, **all** **the** **while** **studying** **the** newly revealed strata **and** **collecting** **all** **the** fossils **he** **could** **find**. Smith **used** **mail** **coaches** **to** **travel** **as** **much** **as** 10,000 **miles** **per** **year**. **In** 1815 **he** **published** **the** **first** **modern** geological **map**, “**A** **Map** **of** **the** Strata **of** **England** **and** Wales **with** **a** **Part** **of** **Scotland**,” **a** **map** **so** meticulously **researched** **that** **it** **can** **still** **be** **used** **today**.

**In** 1831 **when** Smith **was** finally recognized **by** **the** Geological **Society** **of** **London** **as** **the** “**father** **of** **English** geology,” **it** **was** **not** **only** **for** **his** **maps** **but** **also** **for** **something** **even** **more** **important**. **Ever** **since** **people** **had** **begun** **to** catalog **the** strata **in** **particular** outcrops, **there** **had** **been** **the** **hope** **that** **these** **could** somehow **be** **used** **to** **calculate** geological **time**. **But** **as** **more** **and** **more** accumulations **of** strata **were** cataloged **in** **more** **and** **more** **places**, **it** **became** **clear** **that** **the** sequences **of** **rocks** **sometimes** **differed** **from** region **to** region **and** **that** **no** **rock** **type** **was** **ever** **going** **to** **become** **a** **reliable** **time** marker **throughout** **the** **world**. **Even** **without** **the** **problem** **of** regional **differences**, **rocks** **present** **a** **difficulty** **as** **unique** **time** markers. Quartz **is** quartz—**a** silicon ion **surrounded** **by** **four** **oxygen** ions—**there**’s **no** **difference** **at** **all** **between** **two**-**million**-**year**-**old** Pleistocene quartz **and** Cambrian quartz **created** **over** 500 **million** **years** **ago**.

**As** **he** **collected** fossils **from** strata **throughout** **England**, Smith **began** **to** **see** **that** **the** fossils **told** **a** **different** **story** **from** **the** **rocks**. Particularly **in** **the** younger strata, **the** **rocks** **were** **often** **so** **similar** **that** **he** **had** **trouble** **distinguishing** **the** strata, **but** **he** **never** **had** **trouble** **telling** **the** fossils **apart**. **While** **rock** **between** **two** **consistent** strata **might** **in** **one** **place** **be** shale **and** **in** **another** sandstone, **the** fossils **in** **that** shale **or** sandstone **were** **always** **the** **same**. **Some** fossils endured **through** **so** **many** **millions** **of** **years** **that** **they** **appear** **in** **many** strata, **but** **others** **occur** **only** **in** **a** **few** strata, **and** **a** **few** species **had** **their** **births** **and** extinctions **within** **one** **particular** stratum. Fossils **are** **thus** identifying markers **for** **particular** **periods** **in** **Earth**’s **history**.

**Not** **only** **could** Smith identify **rock** strata **by** **the** fossils **they** **contained**, **he** **could** **also** **see** **a** **pattern** emerging: **certain** fossils **always** **appear** **in** **more** **ancient** sediments, **while** **others** **begin** **to** **be** **seen** **as** **the** strata **become** **more** **recent**. **By** **following** **the** fossils, Smith **was** **able** **to** **put** **all** **the** strata **of** **England**’s **earth** **into** **relative** temporal sequence. **About** **the** **same** **time**, Georges Cuvier **made** **the** **same** **discovery** **while** **studying** **the** **rocks** **around** **Paris**. **Soon** **it** **was** realized **that** **this** principal **of** faunal (**animal**) succession **was** **valid** **not** **only** **in** **England** **or** **France** **but** virtually **everywhere**. **It** **was** actually **a** **principle** **of** floral succession **as** **well**, **because** **plants** **showed** **the** **same** transformation **through** **time** **as** **did** fauna. Limestone may **be** **found** **in** **the** Cambrian **or**—300 **million** **years** **later**—**in** **the** Jurassic strata, **but** **a** trilobite—**the** ubiquitous marine arthropod **that** **had** **its** **birth** **in** **the** Cambrian—**will** **never** **be** **found** **in** Jurassic strata, **nor** **a** **dinosaur** **in** **the** Cambrian.

count: 218

# Official 48-Passage 02 Determining Dinosaur Diet

**Determining** **what** extinct **dinosaurs** **ate** **is** **difficult**, **but** **we** **can** infer **some** **aspects** **of** **their** dietary **preferences**. Traditionally, **this** **information** **has** **been** derived **from** **direct** **evidence**, **such** **as** **stomach** **contents**, **and** indirect **evidence**, **such** **as** establishing **a** correlation **between** **particular** body **characteristics** **and** **diets** **of** **living** **animals** **and** **then** inferring **habits** **for** **dinosaurs**.

**Animals** **such** **as** **house** **cats** **and** **dogs** **have** **large**, stabbing canine **teeth** **at** **the** **front** **of** **the** **mouth** **and** smaller, equally **sharp** **teeth** farther **back** **in** **their** **jaws**. **Many** **of** **these** **animals** **are** **also** **armed** **with** **sharp** **claws**. **The** **advantage** **of** **teeth** **and** **claws** **as** predatory **tools** **is** **obvious**. **Now** **consider** **animals** **like** **cows**, **horses**, **rabbits**, **and** **mice**. **These** **animals** **have** **flat** **teeth** **at** **the** **back** **of** **the** **jaw** **that** **are** analogous **to** **and** **have** **the** **same** **function** **as** grindstones. **Unlike** **the** **meat**-**slicing** **and** stabbing **teeth** **of** carnivores, **the** **teeth** **of** **these** **animals** grind **and** shred **plant** **material** **before** digestion.

**More** clues **exist** **in** **other** **parts** **of** **the** skull. **The** **jaw** joint **of** carnivores **such** **as** **dogs** **and** **cats** **has** **the** mechanical **advantage** **of** **being** **at** **the** **same** **level** **as** **the** **tooth** **row**, **allowing** **the** **jaws** **to** **close** **with** tremendous **speed** **and** **forcing** **the** **upper** **teeth** **to** occlude **against** **the** lower **teeth** **with** **great** precision. **In** herbivorous **animals**, **rapid** **jaw** closure **is** **less** **important**. **Because** **the** **flat** **teeth** **of** herbivores **work** **like** grindstones, **however**, **the** **jaws** must **move** **both** **side** **to** **side** **and** **front** **to** **back**. **The** **jaw** joints **of** **many** **advanced** herbivores, **such** **as** **cows**, **lie** **at** **a** **different** **level** **than** **the** **tooth** **row**, **allowing** transverse **tearing**, shredding, **and** compression **of** **plant** **material**. **If** **we** extend **such** observations **to** extinct **dinosaurs**, **we** **can** infer dietary **preferences** (**such** **as** carnivory **and** herbivory), **even** **though** **we** cannot **determine** **the** **exact** **diet**. **The** **duck**-**billed** **dinosaurs** **known** **as** hadrosaurs **are** **a** **good** **example** **of** **a** **group** **whose** **jaw** joint **is** **below** **the** **level** **of** **the** **tooth** **row**, **which** **probably** **helped** **them** grind **up** **tough**, fibrous vegetation.

Paleontologists **would** **like** **to** **be** **much** **more** **specific** **about** **a** **dinosaur**’s **diet** **than** **simply** differentiating carnivore **from** herbivore. **This** finer **level** **of** resolution **requires** **direct** fossil **evidence** **of** **dinosaur** **meals**. **Stomach** **contents** **are** **only** rarely **preserved**, **but** **when** **present**, **allow** us **to** **determine** **exactly** **what** **these** **animals** **were** **eating**.

**In** **the** **stomach** **contents** **of** specimens **of** Coelophysis (**a** **small**, **long**-**necked** **dinosaur**) **are** **bones** **from** juvenile **animals** **of** **the** **same** species. **At** **one** **time**, **these** **were** **thought** **to** **represent** embryonic **animals**, **suggesting** **that** **this** **small** **dinosaur** **gave** **birth** **to** **live** **young** **rather** **than** **laying** **eggs**. Further **research** indicated **that** **the** **small** **dinosaurs** **were** **too** **large** **and** **too** **well** **developed** **to** **be** prehatchling **young**. **In** **addition**, **the** juveniles **inside** **the** body cavity **were** **of** **different** **sizes**. **All** **the** **evidence** **points** **to** **the** **conclusion** **that** **these** **are** **the** **remains** **of** prey items **and** **that**, **as** an **adult**, Coelophysis **was** **at** **least** **in** **part** **a** cannibal.

Fossilized **stomach** **contents** **are** **not** **restricted** **to** carnivorous **dinosaurs**. **In** **a** **few** **rare** **cases**, **most** **of** **them** “mummies” (unusually **well** **preserved** specimens), fossilized **plant** **remains** **have** **been** **found** **inside** **the** body cavity **of** hadrosaurs. **Some** paleontologists **have** **argued** **that** **these** **represent** **stream** accumulations **rather** **than** **final** **meals**. **The** **best** **known** **of** **these** **cases** **is** **the** **second** Edmontosaurus mummy **collected** **by** **the** Sternbergs. **In** **the** **chest** cavity **of** **this** specimen, **which** **is** **housed** **in** **the** Senckenberg **Museum** **in** **Germany**, **are** **the** fossil **remains** **of** conifer **needles**, twigs, **seeds**, **and** **fruits**. **Similar** **finds** **in** Corythosaurus specimens **from** Alberta, **Canada**, **have** **also** **been** **reported**, indicating **that** **at** **least** **two** **kinds** **of** **Late** Cretaceous hadrosaurs **fed** **on** **the** **sorts** **of** **trees** **that** **are** **common** **in** **today**’s boreal woodlands.

**A** **second** **form** **of** **direct** **evidence** **comes** **from** coprolites (fossilized bodily **waste**). **Several** **dinosaur** fossil localities **preserve** coprolites. Coprolites yield unequivocal **evidence** **about** **the** dietary **habits** **of** **dinosaurs**. **Many** **parts** **of** **plants** **and** **animals** **are** **extremely** resistant **to** **the** digestive **systems** **of** **animals** **and** **pass** completely **through** **the** body **with** **little** **or** **no** alteration. **Study** **of** coprolites **has** indicated **that** **the** **diets** **of** **some** herbivorous **dinosaurs** **were** relatively **diverse**, **while** **other** **dinosaurs** **appear** **to** **have** **been** **specialists**, **feeding** **on** **particular** **types** **of** **plants**. **The** **problem** **with** inferring **diets** **from** coprolites **is** **the** **difficulty** **in** accurately **associating** **a** **particular** coprolite **with** **a** **specific** **dinosaur**.

count: 218

# Official 40-Passage 03 Amphibian Thermoregulation

**In** contrast **to** mammals **and** **birds**, amphibians **are** **unable** **to** **produce** thermal energy **through** **their** metabolic **activity**, **which** **would** **allow** **them** **to** regulate **their** body **temperature** **independent** **of** **the** **surrounding** **or** ambient **temperature**. **However**, **the** **idea** **that** amphibians **have** **no** **control** whatsoever **over** **their** body **temperature** **has** **been** **proven** **false** **because** **their** body **temperature** **does** **not** **always** **correspond** **to** **the** **surrounding** **temperature**. **While** amphibians **are** **poor** thermoregulators, **they** **do** **exercise** **control** **over** **their** body **temperature** **to** **a** **limited** **degree**.

Physiological **adaptations** **can** **assist** amphibians **in** colonizing habitats **where** **extreme** **conditions** prevail. **The** tolerance **range** **in** body **temperature** **represents** **the** **range** **of** **temperatures** **within** **which** **a** species **can** **survive**. **One** species **of** **North** **American** newt **is** **still** **active** **when** **temperatures** **drop** **to** -2ºC **while** **one** **South** **American** **frog** **feels** **comfortable** **even** **when** **temperatures** **rise** **to** 41ºC—**the** highest body **temperature** **measured** **in** **a** **free**-**ranging** amphibian. Recently **it** **has** **been** **shown** **that** **some** **North** **American** **frog** **and** toad species **can** **survive** **up** **to** **five** **days** **with** **a** body **temperature** **of** -6ºC **with** **approximately** **one**-**third** **of** **their** body fluids **frozen**. **The** **other** **tissues** **are** **protected** **because** **they** **contain** **the** **frost**-protective **agents** glycerin **or** glucose. Additionally, **in** **many** species **the** tolerance **boundaries** **are** **flexible** **and** **can** **change** **as** **a** **result** **of** acclimatization (**long**-**term** exposure **to** **particular** **conditions**).

**Frog** species **that** **remain** **exposed** **to** **the** **sun** despite **high** diurnal (daytime) **temperatures** exhibit **some** fascinating modifications **in** **the** **skin** structure **that** **function** **as** morphological **adaptations**. **Most** amphibian **skin** **is** fully **water** permeable **and** **is** **therefore** **not** **a** **barrier** **against** evaporation **or** **solar** **radiation**. **The** **African** savanna **frog** Hyperolius viridiflavus **stores** guanine crystals **in** **its** **skin**, **which** enable **it** **to** **better** **reflect** **solar** **radiation**, **thus** **providing** **protection** **against** overheating. **The** **tree** **frog** Phyllomedusa sauvagei **responds** **to** evaporative **losses** **with** gland secretions **that** **provide** **a** greasy **film** **over** **its** **entire** body **that** **helps** **prevent** desiccation (dehydration).

**However**, behavior **is** **by** **far** **the** **most** **important** factor **in** thermoregulation. **The** principal elements **in** behavioral thermoregulation **are** basking (heliothermy), **heat** **exchange** **with** substrates **such** **as** **rock** **or** **earth** (thigmothermy), **and** diurnal **and** **annual** avoidance behaviors, **which** **include** **moving** **to** **shelter** **during** **the** **day** **for** **cooling** **and** **hibernating** **or** estivating (**reducing** **activity** **during** **cold** **or** **hot** **weather**, respectively). Heliothermy **is** **especially** **common** **among** **frogs** **and** toads: **it** **allows** **them** **to** **increase** **their** body **temperature** **by** **more** **than** 10ºC. **The** Andean toad Bufo spinulosus **exposes** **itself** **immediately** after **sunrise** **on** moist **ground** **and** **attains** **its** **preferred** body **temperature** **by** **this** **means**, **long** **before** **either** **ground** **or** **air** **is** correspondingly **warmed**. **A** positive **side** **effect** **of** **this** **approach** **is** **that** **it** **accelerates** **the** digestion **of** **the** prey **consumed** overnight, **thus** **also** **accelerating** **growth**. Thigmothermy **is** **a** behavior **present** **in** **most** amphibians, **although** **pressing** **against** **the** **ground** **serves** **a** dual **purpose**: **heat** absorption **by** conductivity **and** **water** absorption **through** **the** **skin**. **The** **effect** **of** thigmothermy **is** **especially** **evident** **in** **the** Andean toad **during** **rainfall**: **its** body **temperature** **corresponds** **to** **the** **temperature** **of** **the** **warm** **earth** **and** **not** **to** **the** **much** cooler **air** **temperature**.

Avoidance behavior **occurs** **whenever** physiological **and** morphological **adaptations** **are** insufficient **to** maintain body **temperature** **within** **the** **vital** **range**. Nocturnal **activity** **in** amphibians **with** **low** tolerance **for** **high** ambient **temperatures** **is** **a** **typical** thermoregulatory behavior **of** avoidance. Seasonal avoidance behavior **is** **extremely** **important** **in** **many** amphibians. Species **whose** habitat **lies** **in** **the** temperate latitudes **are** confronted **by** lethal **low** **temperatures** **in** **winter**, **while** species dwelling **in** arid **and** semi-arid regions **are** **exposed** **to** **long** **dry**, **hot** **periods** **in** **summer**.

**In** amphibians **hibernation** **occurs** **in** **mud** **or** **deep** **holes** **away** **from** **frost**. **North** **of** **the** Pyrenees **Mountains**, **the** natterjack toad **offers** **a** **good** **example** **of** **hibernation**, **passing** **the** **winter** **dug** **deep** **into** sandy **ground**. Conversely, natterjacks **in** **southern** **Spain** **remain** **active** **during** **the** **mild** **winters** **common** **to** **the** region **and** **are** **instead** **forced** **into** inactivity **during** **the** **dry**, **hot** **summer** **season**. **Summer** estivation **also** **occurs** **by** burrowing **into** **the** **ground** **or** **hiding** **in** **cool**, **deep** **rock** crevasses **to** **avoid** desiccation **and** lethal ambient **temperatures**. Amphibians **are** **therefore** **hardly** **at** **the** **mercy** **of** ambient **temperatures**, **since** **by** **means** **of** **the** mechanisms **described** **above** **they** **are** **more** **than** **able** **to** **exercise** **some** **control** **over** **their** body **temperature**.

count: 218

# Official 49-Passage 01 Ancient Coastlines

**Information** **on** **past** **climates** **is** primarily **of** relevance **to** archaeology **because** **of** **what** **it** **tells** us **about** **the** **effects** **on** **the** **land** **and** **on** **the** resources **that** **people** **needed** **to** **survive**. **The** **most** crucial **effect** **of** **climate** **was** **on** **the** sheer **quantity** **of** **land** **available** **in** **each** **period**, measurable **by** **studying** **ancient** coastlines. **These** **have** **changed** constantly **through** **time**, **even** **in** relatively **recent** **periods**, **as** **can** **be** **seen** **from** **the** Neolithic **stone** **circle** **of** Er Lannic, **in** Brittany, **France** (**once** **inland** **but** **now** **half** submerged **on** an **island**) **or** medieval **villages** **in** **east** Yorkshire, **England**, **that** **have** tumbled **into** **the** **sea** **in** **the** **last** **few** **centuries** **as** **the** **North** **Sea** gnaws **its** **way** westward **and** erodes **the** cliffs. Conversely, silts **deposited** **by** **rivers** **sometimes** **push** **the** **sea** farther **back**, **creating** **new** **land**, **as** **at** Ephesus **in** **western** **Turkey**, **a** **port** **on** **the** **coast** **in** Roman **times** **but** **today** **some** **five** kilometers **inland**.

Nevertheless, **for** archaeologists **concerned** **with** **the** **long** **periods** **of** **time** **of** **the** Paleolithic **period** **there** **are** variations **in** coastlines **of** **much** greater magnitude **to** **consider**. **The** expansion **and** contraction **of** **the** continental glaciers **caused** **huge** **and** uneven **rises** **and** **falls** **in** **sea** **levels** **worldwide**. **When** **the** **ice** **sheets** **grew**, **the** **sea** **level** **would** **drop** **as** **water** **became** **locked** **up** **in** **the** glaciers; **when** **the** **ice** melted, **the** **sea** **level** **would** **rise** **again**. **Falls** **in** **sea** **level** **often** **exposed** **a** **number** **of** **important** **land** **bridges**, **such** **as** **those** **linking** Alaska **to** **northeast** **Asia** **and** **Britain** **to** **northwest** **Europe**, **a** **phenomenon** **with** **far**-**reaching** **effects** **not** **only** **on** **human** colonization **of** **the** **globe** **but** **also** **on** **the** **environment** **as** **a** **whole**—**the** flora **and** fauna **of** isolated **or** insular **areas** **were** radically **and** **often** irreversibly **affected**. **Between** Alaska **and** **Asia** **today** **lies** **the** Bering **Strait**, **which** **is** **so** **shallow** **that** **a** **fall** **in** **sea** **level** **of** **only** **four** meters **would** **turn** **it** **into** **a** **land** **bridge**. **When** **the** **ice** **sheets** **were** **at** **their** greatest extent **some** 18,000 **years** **ago** (**the** glacial **maximum**), **it** **is** **thought** **that** **the** **fall** **was** **about** 120 meters, **which** **therefore** **created** **not** **merely** **a** **bridge** **but** **a** **vast** **plain**, 1,000 kilometers **from** **the** **north** **to** **the** **south**, **which** **has** **been** **called** Beringia. **The** **existence** **of** Beringia (**and** **the** extent **to** **which** **it** **could** **have** **supported** **human** **life**) **is** **one** **of** **the** crucial **pieces** **of** **evidence** **in** **the** **continuing** **debate** **about** **the** **likely** route **and** **date** **of** **human** colonization **of** **the** **New** **World**.

**The** **assessment** **of** **past** **rises** **and** **falls** **in** **sea** **level** **requires** **study** **of** submerged **land** **surfaces** **off** **the** **coast** **and** **of** **raised** **or** elevated **beaches** **on** **land**. **Raised** **beaches** **are** remnants **of** **former** coastlines **at** higher **levels** **relative** **to** **the** **present** shoreline **and** visible, **for** instance, **along** **the** Californian **coast** **north** **of** San Francisco. **The** **height** **of** **a** **raised** **beach** **above** **the** **present** shoreline, **however**, **does** **not** generally **give** **a** **straightforward** indication **of** **the** **height** **of** **a** **former** **sea** **level**. **In** **the** **majority** **of** **cases**, **the** **beaches** **lie** **at** **a** higher **level** **because** **the** **land** **has** **been** **raised** **up** **through** isostatic uplift **or** tectonic **movements**. Isostatic uplift **of** **the** **land** **occurs** **when** **the** **weight** **of** **ice** **is** **removed** **as** **temperatures** **rise**, **as** **at** **the** **end** **of** an **ice** **age**; **it** **has** **affected** coastlines, **for** **example**, **in** Scandinavia, **Scotland**, Alaska, **and** Newfoundland **during** **the** postglacial **period**. Tectonic **movements** involve displacements **in** **the** **plates** **that** **make** **up** **Earth**’s crust; **Middle** **and** **Late** Pleistocene **raised** **beaches** **in** **the** Mediterranean **are** **one** instance **of** **such** **movements**.

**Raised** **beaches** **often** **consist** **of** **areas** **of** **sand**, pebbles, **or** dunes, **sometimes** **containing** **seashells** **or** **piles** **of** debris comprising shells **and** **bones** **of** marine **animals** **used** **by** **humans**. **In** **Tokyo** **Bay**, **for** **example**, shell mounds **of** **the** Jomon **period** (**about** 10,000 **to** 300 B.C.E.) **mark** **the** **position** **of** **the** shoreline **at** **a** **time** **of** **maximum** inundation **by** **the** **sea** (6,500–5,500 **years** **ago**), **when**, **through** tectonic **movement**, **the** **sea** **was** **three** **to** **five** meters higher **in** **relation** **to** **the** **contemporary** landmass **of** **Japan** **than** **at** **present**. **Analysis** **of** **the** shells **themselves** **has** **confirmed** **the** **changes** **in** marine topography, **for** **it** **is** **only** **during** **the** **maximum** phase **that** subtropical species **of** mollusc **are** **present**, indicating **a** higher **water** **temperature**.

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 Neolithic: **related** **to** **the** **latest** **period** **of** **the** **Stone** **Age**, **between** **about** 8000 B.C.E. **and** 5000 B.C.E.

 Paleolithic: **the** **early** **part** **of** **the** **Stone** **Age**, **from** 750,000 **to** 15,000 **years** **ago**

count: 218

# Official 02-Passage 01 Desert Formation

**The** **deserts**, **which** **already** occupy **approximately** **a** **fourth** **of** **the** **Earth**’s **land** **surface**, **have** **in** **recent** **decades** **been** **increasing** **at** an **alarming** **pace**.  **The** expansion **of** desertlike **conditions** **into** **areas** **where** **they** **did** **not** previously **exist** **is** **called** desertification. **It** **has** **been** estimated **that** an additional **one**-**fourth** **of** **the** **Earth**’s **land** **surface** **is** threatened **by** **this** **process**.

Desertification **is** **accomplished** primarily **through** **the** **loss** **of** stabilizing **natural** vegetation **and** **the** subsequent **accelerated** erosion **of** **the** **soil** **by** **wind** **and** **water**.  **In** **some** **cases** **the** **loose** **soil** **is** **blown** completely **away**, **leaving** **a** stony **surface**.  **In** **other** **cases**, **the** finer particles may **be** **removed**, **while** **the** **sand**-**sized** particles **are** **accumulated** **to** **form** **mobile** **hills** **or** ridges **of** **sand**.

**Even** **in** **the** **areas** **that** retain **a** **soil** **cover**, **the** reduction **of** vegetation typically **results** **in** **the** **loss** **of** **the** **soil**’s **ability** **to** **absorb** substantial **quantities** **of** **water**.  **The** impact **of** raindrops **on** **the** **loose** **soil** **tends** **to** transfer **fine** **clay** particles **into** **the** tiniest **soil** **spaces**, **sealing** **them** **and** **producing** **a** **surface** **that** **allows** **very** **little** **water** penetration.  **Water** absorption **is** greatly **reduced**, consequently runoff **is** **increased**, **resulting** **in** **accelerated** erosion **rates**.  **The** gradual **drying** **of** **the** **soil** **caused** **by** **its** diminished **ability** **to** **absorb** **water** **results** **in** **the** further **loss** **of** vegetation, **so** **that** **a** **cycle** **of** progressive **surface** deterioration **is** established.

**In** **some** regions, **the** **increase** **in** **desert** **areas** **is** **occurring** largely **as** **the** **result** **of** **a** **trend** **toward** **drier** climatic **conditions**. **Continued** gradual global **warming** **has** **produced** an **increase** **in** aridity **for** **some** **areas** **over** **the** **past** **few** **thousand** **years**.  **The** **process** may **be** **accelerated** **in** subsequent **decades** **if** global **warming** **resulting** **from** **air** **pollution** seriously **increases**.

**There** **is** **little** **doubt**, **however**, **that** desertification **in** **most** **areas** **results** primarily **from** **human** **activities** **rather** **than** **natural** **processes**.  **The** semiarid **lands** **bordering** **the** **deserts** **exist** **in** **a** **delicate** ecological **balance** **and** **are** **limited** **in** **their** **potential** **to** **adjust** **to** **increased** environmental **pressures**. **Expanding** **populations** **are** **subjecting** **the** **land** **to** **increasing** **pressures** **to** **provide** **them** **with** **food** **and** **fuel**.  **In** **wet** **periods**, **the** **land** may **be** **able** **to** **respond** **to** **these** **stresses**.  **During** **the** **dry** **periods** **that** **are** **common** **phenomena** **along** **the** **desert** margins, **though**, **the** **pressure** **on** **the** **land** **is** **often** **far** **in** excess **of** **its** diminished capacity, **and** desertification **results**.

**Four** **specific** **activities** **have** **been** identified **as** **major** contributors **to** **the** desertification **processes**: overcultivation, overgrazing, **firewood** **gathering**, **and** overirrigation.  **The** cultivation **of** **crops** **has** **expanded** **into** progressively **drier** regions **as** **population** densities **have** **grown**.  **These** regions **are** **especially** **likely** **to** **have** **periods** **of** **severe** dryness, **so** **that** **crop** **failures** **are** **common**.  **Since** **the** **raising** **of** **most** **crops** necessitates **the** prior removal **of** **the** **natural** vegetation, **crop** **failures** **leave** extensive tracts **of** **land** devoid **of** **a** **plant** **cover** **and** susceptible **to** **wind** **and** **water** erosion.

**The** **raising** **of** livestock **is** **a** **major** economic **activity** **in** semiarid **lands**, **where** **grasses** **are** generally **the** dominant **type** **of** **natural** vegetation. **The** **consequences** **of** an excessive **number** **of** livestock grazing **in** an **area** **are** **the** reduction **of** **the** vegetation **cover** **and** **the** trampling **and** pulverization **of** **the** **soil**.  **This** **is** **usually** **followed** **by** **the** **drying** **of** **the** **soil** **and** **accelerated** erosion.

**Firewood** **is** **the** **chief** **fuel** **used** **for** **cooking** **and** **heating** **in** **many** **countries**.  **The** **increased** **pressures** **of** **expanding** **populations** **have** **led** **to** **the** removal **of** woody **plants** **so** **that** **many** **cities** **and** **towns** **are** **surrounded** **by** **large** **areas** completely **lacking** **in** **trees** **and** shrubs. **The** **increasing** **use** **of** **dried** **animal** **waste** **as** **a** **substitute** **fuel** **has** **also** **hurt** **the** **soil** **because** **this** **valuable** **soil** conditioner **and** source **of** **plant** nutrients **is** **no** longer **being** **returned** **to** **the** **land**.

**The** **final** **major** **human** **cause** **of** desertification **is** **soil** salinization **resulting** **from** overirrigation. Excess **water** **from** **irrigation** **sinks** **down** **into** **the** **water** **table**.  **If** **no** drainage **system** **exists**, **the** **water** **table** **rises**, **bringing** dissolved **salts** **to** **the** **surface**.  **The** **water** evaporates **and** **the** **salts** **are** **left** **behind**, **creating** **a** **white** crustal layer **that** **prevents** **air** **and** **water** **from** **reaching** **the** underlying **soil**.

**The** **extreme** seriousness **of** desertification **results** **from** **the** **vast** **areas** **of** **land** **and** **the** tremendous **numbers** **of** **people** **affected**, **as** **well** **as** **from** **the** **great** **difficulty** **of** reversing **or** **even** **slowing** **the** **process**.  **Once** **the** **soil** **has** **been** **removed** **by** erosion, **only** **the** **passage** **of** **centuries** **or** millennia **will** enable **new** **soil** **to** **form**.  **In** **areas** **where** considerable **soil** **still** **remains**, **though**, **a** rigorously enforced program **of** **land** **protection** **and** **cover**-**crop** **planting** may **make** **it** **possible** **to** reverse **the** **present** deterioration **of** **the** **surface**.

count: 218

# Official 23-Passage 01 Urban Climates

**The** **city** **is** an **extraordinary** processor **of** **mass** **and** energy **and** **has** **its** **own** metabolism. **A** **daily** input **of** **water**, **food**, **and** energy **of** **various** **kinds** **is** **matched** **by** an **output** **of** sewage, **solid** **waste**, **air** pollutants, energy, **and** **materials** **that** **have** **been** **transformed** **in** **some** **way**. **The** **quantities** involved **are** enormous. **Many** **aspects** **of** **this** energy **use** **affect** **the** **atmosphere** **of** **a** **city**, particularly **in** **the** **production** **of** **heat**.

**In** **winter** **the** **heat** **produced** **by** **a** **city** **can** **equal** **or** surpass **the** **amount** **of** **heat** **available** **from** **the** **Sun**. **All** **the** **heat** **that** **warms** **a** **building** **eventually** transfers **to** **the** **surrounding** **air**, **a** **process** **that** **is** quickest **where** **houses** **are** poorly insulated. **But** an automobile **produces** **enough** **heat** **to** **warm** an **average** **house** **in** **winter**; **and** **if** **a** **house** **were** perfectly insulated, **one** **adult** **could** **also** **produce** **more** **than** **enough** **heat** **to** **warm** **it**. **Therefore**, **even** **without** **any** industrial **production** **of** **heat**, an **urban** **area** **tends** **to** **be** warmer **than** **the** **countryside** **that** **surrounds** **it**.

**The** **burning** **of** **fuel**, **such** **as** **by** **cars**, **is** **not** **the** **only** source **of** **this** **increased** **heat**. **Two** **other** factors **contribute** **to** **the** higher overall **temperature** **in** **cities**. **The** **first** **is** **the** **heat** capacity **of** **the** **materials** **that** constitute **the** **city**, **which** **is** typically dominated **by** **concrete** **and** asphalt. **During** **the** **day**, **heat** **from** **the** **Sun** **can** **be** **conducted** **into** **these** **materials** **and** **stored**—**to** **be** released **at** **night**. **But** **in** **the** **countryside** **materials** **have** **a** significantly lower **heat** capacity **because** **a** vegetative **blanket** **prevents** **heat** **from** **easily** **flowing** **into** **and** **out** **of** **the** **ground**. **The** **second** factor **is** **that** radiant **heat** **coming** **into** **the** **city** **from** **the** **Sun** **is** **trapped** **in** **two** **ways**: (1) **by** **a** **continuing** series **of** reflections **among** **the** numerous **vertical** **surfaces** **that** **buildings** **present** **and** (2) **by** **the** **dust** dome, **the** cloudlike layer **of** **polluted** **air** **that** **most** **cities** **produce**. Shortwave **radiation** **from** **the** **Sun** **passes** **through** **the** **pollution** dome **more** **easily** **than** **outgoing** longwave **radiation** **does**; **the** **latter** **is** **absorbed** **by** **the** gaseous pollutants **of** **the** dome **and** reradiated **back** **to** **the** **urban** **surface**.

**Cities**, **then**, **are** warmer **than** **the** **surrounding** rural **areas**, **and** **together** **they** **produce** **a** **phenomenon** **known** **as** **the** **urban** **heat** **island**. **Heat** **islands** **develop** **best** **under** **particular** **conditions** **associated** **with** **light** **winds**, **but** **they** **can** **form** **almost** **any** **time**. **The** **precise** configuration **of** **a** **heat** **island** **depends** **on** **several** factors. **For** **example**, **the** **wind** **can** **make** **a** **heat** **island** stretch **in** **the** **direction** **it** **blows**. **When** **a** **heat** **island** **is** **well** **developed**, variations **can** **be** **extreme**; **in** **winter**, **busy** **streets** **in** **cities** **can** **be** 1.7°C warmer **than** **the** **side** **streets**. **Areas** **near** **traffic lights** **can** **be** similarly warmer **than** **the** **areas** **between** **them** **because** **of** **the** **effect** **of** **cars** **standing** **in** **traffic** **instead** **of** **moving**. **The** **maximum** **differences** **in** **temperature** **between** neighboring **urban** **and** rural **environments** **is** **called** **the** **heat**-**island** intensity **for** **that** region. **In** **general**, **the** larger **the** **city**, **the** greater **its** **heat**-**island** intensity. **The** **actual** **level** **of** intensity **depends** **on** **such** factors **as** **the** **physical** layout, **population** density, **and** productive **activities** **of** **a** metropolis.

**The** **surface**-**atmosphere** **relationships** **inside** metropolitan **areas** **produce** **a** **number** **of** climatic peculiarities. **For** **one** **thing**, **the** presence **or** **absence** **of** moisture **is** **affected** **by** **the** **special** **qualities** **of** **the** **urban** **surface**. **With** **much** **of** **the** **built**-**up** landscape impenetrable **by** **water**, **even** **gentle** **rain** **runs** **off** **almost** **immediately** **from** rooftops, **streets**, **and** **parking** **lots**. **Thus**, **city** **surfaces**, **as** **well** **as** **the** **air** **above** **them**, **tend** **to** **be** **drier** **between** episodes **of** **rain**; **with** **little** **water** **available** **for** **the** **cooling** **process** **of** evaporation, **relative** humidities **are** **usually** lower. **Wind** **movements** **are** **also** modified **in** **cities** **because** **buildings** **increase** **the** **friction** **on** **air** **flowing** **around** **them**. **This** **friction** **tends** **to** **slow** **the** **speed** **of** **winds**, **making** **them** **far** **less** efficient **at** dispersing pollutants. **On** **the** **other** **hand**, **air** turbulence **increases** **because** **of** **the** **effect** **of** **skyscrapers** **on** airflow. **Rainfall** **is** **also** **increased** **in** **cities**. **The** **cause** **appears** **to** **be** **in** **part** greater turbulence **in** **the** **urban** **atmosphere** **as** **hot** **air** **rises** **from** **the** **built**-**up** **surface**.

count: 218

# Official 14-Passage 02 Maya Water Problems

**To** **understand** **the** **ancient** Mayan **people** **who** **lived** **in** **the** **area** **that** **is** **today** **southern** **Mexico** **and** **Central** **America** **and** **the** ecological **difficulties** **they** **faced**, **one** must **first** **consider** **their** **environment**, **which** **we** **think** **of** **as** “**jungle**” **or** “tropical rainforest.” **This** **view** **is** inaccurate, **and** **the** **reason** **proves** **to** **be** **important**. **Properly** **speaking**, tropical rainforests **grow** **in** **high**-**rainfall** equatorial **areas** **that** **remain** **wet** **or** humid **all** **year** **round**. **But** **the** Maya **homeland** **lies** **more** **than** **sixteen** **hundred** kilometers **from** **the** equator, **at** latitudes 17 **to** 22 **degrees** **north**, **in** **a** habitat **termed** **a** “seasonal tropical **forest**.” **That** **is**, **while** **there** **does** **tend** **to** **be** **a** **rainy** **season** **from** **May** **to** **October**, **there** **is** **also** **a** **dry** **season** **from** **January** **through** **April**. **If** **one** **focuses** **on** **the** **wet** **months**, **one** **calls** **the** Maya **homeland** **a** “seasonal tropical **forest**”; **if** **one** **focuses** **on** **the** **dry** **months**, **one** **could** **instead** **describe** **it** **as** **a** “seasonal **desert**”.

**From** **north** **to** **south** **in** **the** Yucatan Peninsula, **where** **the** Maya **lived**, **rainfall** **ranges** **from** 18 **to** 100 **inches** (457 **to** 2,540 millimeters) **per** **year**, **and** **the** **soils** **become** thicker, **so** **that** **the** **southern** peninsula **was** agriculturally **more** productive **and** **supported** denser **populations**. **But** **rainfall** **in** **the** Maya **homeland** **is** unpredictably variable **between** **years**; **some** **recent** **years** **have** **had** **three** **or** **four** **times** **more** **rain** **than** **other** **years**. **As** **a** **result**, **modern** **farmers** **attempting** **to** **grow** **corn** **in** **the** **ancient** Maya **homelands** **have** **faced** **frequent** **crop** **failures**, **especially** **in** **the** **north**. **The** **ancient** Maya **were** presumably **more** **experienced** **and** **did** **better**, **but** nevertheless **they** **too** must **have** **faced** **risks** **of** **crop** **failures** **from** droughts **and** **hurricanes**.

**Although** **southern** Maya **areas** **received** **more** **rainfall** **than** **northern** **areas**, **problems** **of** **water** **were** paradoxically **more** **severe** **in** **the** **wet** **south**. **While** **that** **made** **things** **hard** **for** **ancient** Maya **living** **in** **the** **south**, **it** **has** **also** **made** **things** **hard** **for** **modern** archaeologists **who** **have** **difficulty** **understanding** **why** **ancient** droughts **caused** bigger **problems** **in** **the** **wet** **south** **than** **in** **the** **dry** **north**. **The** **likely** **explanation** **is** **that** an **area** **of** **underground** freshwater underlies **the** Yucatan Peninsula, **but** **surface** elevation **increases** **from** **north** **to** **south**, **so** **that** **as** **one** **moves** **south** **the** **land** **surface** **lies** increasingly higher **above** **the** **water** **table**. **In** **the** **northern** peninsula **the** elevation **is** sufficiently **low** **that** **the** **ancient** Maya **were** **able** **to** **reach** **the** **water** **table** **at** **deep** sinkholes **called** cenotes, **or** **at** **deep** **caves**. **In** **low**-elevation **north** coastal **areas** **without** sinkholes, **the** Maya **would** **have** **been** **able** **to** **get** **down** **to** **the** **water** **table** **by** **digging** **wells** **up** **to** 75 **feet** (22 meters) **deep**. **But** **much** **of** **the** **south** **lies** **too** **high** **above** **the** **water** **table** **for** cenotes **or** **wells** **to** **reach** **down** **to** **it**. **Making** **matters** **worse**, **most** **of** **the** Yucatan Peninsula **consists** **of** karst, **a** porous sponge-**like** limestone terrain **where** **rain** **runs** **straight** **into** **the** **ground** **and** **where** **little** **or** **no** **surface** **water** **remains** **available**.

**How** **did** **those** dense **southern** Maya **populations** **deal** **with** **the** **resulting** **water** **problem**? **It** initially **surprises** us **that** **many** **of** **their** **cities** **were** **not** **built** **next** **to** **the** **rivers** **but** **instead** **on** **high** terrain **in** **rolling** uplands. **The** **explanation** **is** **that** **the** Maya excavated depressions, **or** modified **natural** depressions, **and** **then** **plugged** **up** **leaks** **in** **the** karst **by** plastering **the** **bottoms** **of** **the** depressions **in** **order** **to** **create** reservoirs, **which** **collected** **rain** **from** **large** plastered catchment **basins** **and** **stored** **it** **for** **use** **in** **the** **dry** **season**. **For** **example**, reservoirs **at** **the** Maya **city** **of** Tikal **held** **enough** **water** **to** **meet** **the** **drinking** **water** **needs** **of** **about** 10,000 **people** **for** **a** **period** **of** 18 **months**. **At** **the** **city** **of** Coba **the** Maya **built** dikes **around** **a** **lake** **in** **order** **to** **raise** **its** **level** **and** **make** **their** **water** **supply** **more** **reliable**. **But** **the** inhabitants **of** Tikal **and** **other** **cities** dependent **on** reservoirs **for** **drinking** **water** **would** **still** **have** **been** **in** **deep** **trouble** **if** 18 **months** **passed** **without** **rain** **in** **a** prolonged drought. **A** shorter drought **in** **which** **they** exhausted **their** **stored** **food** **supplies** **might** **already** **have** **gotten** **them** **in** **deep** **trouble**, **because** **growing** **crops** **required** **rain** **rather** **than** reservoirs.

count: 218

# Official 45-Passage 02 Wind pollination

    Pollen, **a** powdery substance, **which** **is** **produced** **by** **flowering** **plants** **and** **contains** **male** reproductive **cells**, **is** **usually** **carried** **from** **plant** **to** **plant** **by** **insects** **or** **birds**, **but** **some** **plants** **rely** **on** **the** **wind** **to** **carry** **their** pollen. **Wind** pollination **is** **often** **seen** **as** **being** **primitive** **and** wasteful **in** costly pollen **and** **yet** **it** **is** surprisingly **common**, **especially** **in** higher latitudes. **Wind** **is** **very** **good** **at** **moving** pollen **a** **long** **way**; pollen **can** **be** **blown** **for** **hundreds** **of** kilometers, **and** **only** **birds** **can** **get** pollen **anywhere** **near** **as** **far**. **The** **drawback** **is** **that** **wind** **is** obviously unspecific **as** **to** **where** **it** **takes** **the** pollen. **It** **is** **like** **trying** **to** **get** **a** **letter** **to** **a** **friend** **at** **the** **other** **end** **of** **the** **village** **by** **climbing** **onto** **the** **roof** **and** **throwing** an armful **of** **letters** **into** **the** **air** **and** **hoping** **that** **one** **will** **end** **up** **in** **the** **friend**’s **garden**. **For** **the** relatively **few** dominant **tree** species **that** **make** **up** temperate **forests**, **where** **there** **are** **many** individuals **of** **the** **same** species **within** pollen **range**, **this** **is** **quite** **a** **safe** gamble. **If** **a** **number** **of** **people** **in** **the** **village** **were** **throwing** **letters** **off** **roofs**, **your** **friend** **would** **be** **bound** **to** **get** **one**. **By** contrast, **in** **the** tropics, **where** **each** **tree** species **has** **few**, widely scattered individuals, **the** **chance** **of** **wind** **blowing** pollen **to** **another** individual **is** sufficiently **slim** **that** **animals** **are** **a** safer bet **as** transporters **of** pollen. **Even** **tall** **trees** **in** **the** tropics **are** **usually** **not** **wind** pollinated despite **being** **in** **windy** **conditions**. **In** **a** **similar** **way**, **trees** **in** temperate **forests** **that** **are** **insect** pollinated **tend** **to** **grow** **as** solitary, widely **spread** individuals.

**Since** **wind**-pollinated **flowers** **have** **no** **need** **to** **attract** **insects** **or** **other** **animals**, **they** **have** dispensed **with** **bright** petals, nectar, **and** scent. **These** **are** **at** **best** **a** **waste** **and** **at** **worst** an impediment **to** **the** transfer **of** pollen **in** **the** **air**. **The** **result** **is** insignificant-**looking** **flowers** **and** catkins (dense cylindrical clusters **of** **small**, petalless **flowers**).

**Wind** pollination **does**, **of** **course**, **require** **a** **lot** **of** pollen. Birch **and** hazel **trees** **can** **produce** 5.5 **and** 4 **million** **grains** **per** catkin, respectively. **There** **are** **various** **adaptations** **to** **help** **as** **much** **of** **the** pollen **go** **as** **far** **as** **possible**. **Most** deciduous **wind**-pollinated **trees** (**which** shed **their** **leaves** **every** **fall**) **produce** **their** pollen **in** **the** **spring** **while** **the** **branches** **are** **bare** **of** **leaves** **to** **reduce** **the** **surrounding** **surfaces** **that** “**compete**” **with** **the** stigmas (**the** **part** **of** **the** **flower** **that** **receives** **the** pollen) **for** pollen. Evergreen conifers, **which** **do** **not** shed **their** **leaves**, **have** **less** **to** **gain** **from** **spring** **flowering**, **and**, **indeed**, **some** **flower** **in** **the** **autumn** **or** **winter**.

    Pollen **produced** higher **in** **the** **top** **branches** **is** **likely** **to** **go** farther: **it** **is** windier (**and** gustier) **and** **the** pollen **can** **be** **blown** farther **before** **hitting** **the** **ground**. Moreover, dangling catkins **like** hazel **hold** **the** pollen **in** **until** **the** **wind** **is** **strong** **enough** **to** **bend** **them**, ensuring **that** pollen **is** **only** shed **into** **the** **air** **when** **the** **wind** **is** **blowing** **hard**. **Weather** **is** **also** **important**. Pollen **is** shed primarily **when** **the** **air** **is** **dry** **to** **prevent** **too** **much** **sticking** **to** **wet** **surfaces** **or** **being** **knocked** **out** **of** **the** **air** **by** **rain**. Despite **these** **adaptations**, **much** **of** **the** pollen **fails** **to** **leave** **the** **top** **branches**, **and** **only** **between** 0.5 **percent** **and** 40 **percent** **gets** **more** **than** 100 meters **away** **from** **the** **parent**. **But** **once** **this** **far**, significant **quantities** **can** **go** **a** kilometer **or** **more**. **Indeed**, pollen **can** **travel** **many** **thousands** **of** kilometers **at** **high** **altitudes**. **Since** **all** **this** pollen **is** **floating** **around** **in** **the** **air**, **it** **is** **no** **wonder** **that** **wind**-pollinated **trees** **are** **a** **major** source **of** allergies.

**Once** **the** pollen **has** **been** **snatched** **by** **the** **wind**, **the** fate **of** **the** pollen **is** obviously **up** **to** **the** vagaries **of** **the** **wind**, **but** **not** **everything** **is** **left** **to** **chance**. Windborne pollen **is** **dry**, **rounded**, **smooth**, **and** generally smaller **than** **that** **of** **insect**-pollinated **plants**. **But** **size** **is** **a** **two**-**edged** **sword**. **Small** **grains** may **be** **blown** farther **but** **they** **are** **also** **more** prone **to** **be** whisked **past** **the** **waiting** stigma **because** smaller particles **tend** **to** **stay** **trapped** **in** **the** **fast**-**moving** **air** **that** **flows** **around** **the** stigma. **But** stigmas **create** turbulence, **which** **slows** **the** **air** **speed** **around** **them** **and** may **help** pollen **stick** **to** **them**.

count: 218

# Official 13-Passage 01 Types of Social Groups

**Life** **places** us **in** **a** **complex** **web** **of** **relationships** **with** **other** **people**. **Our** humanness **arises** **out** **of** **these** **relationships** **in** **the** **course** **of** **social** interaction. Moreover, **our** humanness must **be** sustained **through** **social** interaction—**and** **fairly** constantly **so**. **When** an **association** **continues** **long** **enough** **for** **two** **people** **to** **become** **linked** **together** **by** **a** relatively **stable** **set** **of** **expectations**, **it** **is** **called** **a** **relationship**.

**People** **are** **bound** **within** **relationships** **by** **two** **types** **of** **bonds**: expressive **ties** **and** instrumental **ties**. Expressive **ties** **are** **social** **links** **formed** **when** **we** emotionally invest **ourselves** **in** **and** **commit** **ourselves** **to** **other** **people**. **Through** **association** **with** **people** **who** **are** meaningful **to** us, **we** **achieve** **a** **sense** **of** **security**, **love**, acceptance, companionship, **and** **personal** **worth**. Instrumental **ties** **are** **social** **links** **formed** **when** **we** cooperate **with** **other** **people** **to** **achieve** **some** **goal**. Occasionally, **this** may **mean** **working** **with** **instead** **of** **against** **competitors**. **More** **often**, **we** **simply** cooperate **with** **others** **to** **reach** **some** **end** **without** endowing **the** **relationship** **with** **any** larger **significance**.

Sociologists **have** **built** **on** **the** **distinction** **between** expressive **and** instrumental **ties** **to** **distinguish** **between** **two** **types** **of** **groups**: **primary** **and** secondary. **A** **primary** **group** involves **two** **or** **more** **people** **who** **enjoy** **a** **direct**, intimate, cohesive **relationship** **with** **one** **another**. Expressive **ties** predominate **in** **primary** **groups**; **we** **view** **the** **people** **as** **ends** **in** **themselves** **and** **valuable** **in** **their** **own** **right**. **A** secondary **group** entails **two** **or** **more** **people** **who** **are** involved **in** an impersonal **relationship** **and** **have** **come** **together** **for** **a** **specific**, **practical** **purpose**. Instrumental **ties** predominate **in** secondary **groups**; **we** perceive **people** **as** **means** **to** **ends** **rather** **than** **as** **ends** **in** **their** **own** **right**. **Sometimes** **primary** **group** **relationships** evolve **out** **of** secondary **group** **relationships**. **This** **happens** **in** **many** **work** settings. **People** **on** **the** **job** **often** **develop** **close** **relationships** **with** coworkers **as** **they** **come** **to** **share** gripes, **jokes**, gossip, **and** **satisfactions**.

**A** **number** **of** **conditions** enhance **the** likelihood **that** **primary** **groups** **will** **arise**. **First**, **group** **size** **is** **important**. **We** **find** **it** **difficult** **to** **get** **to** **know** **people** **personally** **when** **they** **are** milling **about** **and** dispersed **in** **large** **groups**. **In** **small** **groups** **we** **have** **a** **better** **chance** **to** initiate contact **and** establish rapport **with** **them**. **Second**, **face**-**to**-**face** contact **allows** us **to** **size** **up** **others**. **Seeing** **and** **talking** **with** **one** **another** **in** **close** **physical** proximity **makes** **possible** **a** subtle **exchange** **of** **ideas** **and** **feelings**. **And** **third**, **the** probability **that** **we** **will** **develop** **primary** **group** **bonds** **increases** **as** **we** **have** **frequent** **and** continuous contact. **Our** **ties** **with** **people** **often** deepen **as** **we** interact **with** **them** **across** **time** **and** **gradually** evolve interlocking **habits** **and** **interests**.

**Primary** **groups** **are** **fundamental** **to** us **and** **to** **society**. **First**, **primary** **groups** **are** critical **to** **the** socialization **process**. **Within** **them**, infants **and** **children** **are** **introduced** **to** **the** **ways** **of** **their** **society**. **Such** **groups** **are** **the** breeding **grounds** **in** **which** **we** **acquire** **the** norms **and** **values** **that** **equip** us **for** **social** **life**. Sociologists **view** **primary** **groups** **as** **bridges** **between** individuals **and** **the** larger **society** **because** **they** transmit, mediate, **and** interpret **a** **society**’s cultural **patterns** **and** **provide** **the** **sense** **of** oneness **so** critical **for** **social** solidarity.

**Second**, **primary** **groups** **are** **fundamental** **because** **they** **provide** **the** settings **in** **which** **we** **meet** **most** **of** **our** **personal** **needs**. **Within** **them**, **we** **experience** companionship, **love**, **security**, **and** an overall **sense** **of** **well**-**being**. **Not** surprisingly, sociologists **find** **that** **the** **strength** **of** **a** **group**’s **primary** **ties** **has** implications **for** **the** **group**’s **functioning**. **For** **example**, **the** stronger **the** **primary** **group** **ties** **of** **a** **sports** **team** **playing** **together**, **the** **better** **their** **record** **is**.

**Third**, **primary** **groups** **are** **fundamental** **because** **they** **serve** **as** **powerful** **instruments** **for** **social** **control**. **Their** **members** **command** **and** dispense **many** **of** **the** **rewards** **that** **are** **so** **vital** **to** us **and** **that** **make** **our** **lives** **seem** **worthwhile**. **Should** **the** **use** **of** **rewards** **fail**, **members** **can** frequently **win** **by** **rejecting** **or** threatening **to** ostracize **those** **who** deviate **from** **the** **primary** **group**’s norms. **For** instance, **some** **social** **groups** **employ** shunning (**a** **person** **can** **remain** **in** **the** community, **but** **others** **are** **forbidden** **to** interact **with** **the** **person**) **as** **a** device **to** **bring** **into** **line** individuals **whose** behavior **goes** **beyond** **that** **allowed** **by** **the** **particular** **group**. **Even** **more** **important**, **primary** **groups** define **social** **reality** **for** us **by** structuring **our** **experiences**. **By** **providing** us **with** definitions **of** **situations**, **they** elicit **from** us behavior **that** conforms **to** **group**-devised **meanings**. **Primary** **groups**, **then**, **serve** **both** **as** **carriers** **of** **social** norms **and** **as** enforcers **of** **them**.

count: 217

# Official 11-Passage 02 Orientation and Navigation

**To** **South** Americans, robins **are** **birds** **that** **fly** **north** **every** **spring**. **To** **North** Americans, **the** robins **simply** **vacation** **in** **the** **south** **each** **winter**. Furthermore, **they** **fly** **to** **very** **specific** **places** **in** **South** **America** **and** **will** **often** **come** **back** **to** **the** **same** **trees** **in** **North** **American** **yards** **the** **following** **spring**. **The** **question** **is** **not** **why** **they** **would** **leave** **the** **cold** **of** **winter** **so** **much** **as** **how** **they** **find** **their** **way** **around**. **The** **question** perplexed **people** **for** **years**, **until**, **in** **the** 1950’s, **a** **German** **scientist** **named** Gustave Kramer **provided** **some** **answers** **and**, **in** **the** **process**, **raised** **new** **questions**.

Kramer initiated **important** **new** **kinds** **of** **research** **regarding** **how** **animals** orient **and** navigate. Orientation **is** **simply** **facing** **in** **the** **right** **direction**; navigation involves **finding** **one**’s **way** **from** **point** **A** **to** **point** B.

**Early** **in** **his** **research**, Kramer **found** **that** **caged** migratory **birds** **became** **very** restless **at** **about** **the** **time** **they** **would** normally **have** **begun** migration **in** **the** **wild**. Furthermore, **he** **noticed** **that** **as** **they** fluttered **around** **in** **the** **cage**, **they** **often** launched **themselves** **in** **the** **direction** **of** **their** **normal** migratory route. **He** **then** **set** **up** **experiments** **with** **caged** starlings **and** **found** **that** **their** orientation **was**, **in** **fact**, **in** **the** **proper** migratory **direction** **except** **when** **the** **sky** **was** overcast, **at** **which** **times** **there** **was** **no** **clear** **direction** **to** **their** restless **movements**. Kramer surmised, **therefore**, **that** **they** **were** orienting **according to** **the** **position** **of** **the** **Sun**. **To** **test** **this** **idea**, **he** **blocked** **their** **view** **of** **the** **Sun** **and** **used** **mirrors** **to** **change** **its** **apparent** **position**. **He** **found** **that** **under** **these** **circumstances**, **the** **birds** oriented **with** **respect** **to** **the** **new** “**Sun**.” **They** **seemed** **to** **be** **using** **the** **Sun** **as** **a** **compass** **to** **determine** **direction**. **At** **the** **time**, **this** **idea** **seemed** preposterous. **How** **could** **a** **bird** navigate **by** **the** **Sun** **when** **some** **of** us **lose** **our** **way** **with** **road** **maps**? Obviously, **more** **testing** **was** **in** **order**.

**So**, **in** **another** **set** **of** **experiments**, Kramer **put** identical **food** **boxes** **around** **the** **cage**, **with** **food** **in** **only** **one** **of** **the** **boxes**. **The** **boxes** **were** stationary, **and** **the** **one** **containing** **food** **was** **always** **at** **the** **same** **point** **of** **the** **compass**. **However**, **its** **position** **with** **respect** **to** **the** **surroundings** **could** **be** **changed** **by** revolving **either** **the** inner **cage** **containing** **the** **birds** **or** **the** **outer** **walls**, **which** **served** **as** **the** **background**. **As** **long** **as** **the** **birds** **could** **see** **the** **Sun**, **no** **matter** **how** **their** **surroundings** **were** altered, **they** **went** directly **to** **the** **correct** **food** **box**. **Whether** **the** **box** **appeared** **in** **front** **of** **the** **right** **wall** **or** **the** **left** **wall**, **they** **showed** **no** **signs** **of** confusion. **On** overcast **days**, **however**, **the** **birds** **were** disoriented **and** **had** **trouble** locating **their** **food** **box**.

**In** **experimenting** **with** **artificial** **suns**, Kramer **made** **another** **interesting** **discovery**. **If** **the** **artificial** **Sun** **remained** stationary, **the** **birds** **would** shift **their** **direction** **with** **respect** **to** **it** **at** **a** **rate** **of** **about** 15 **degrees** **per** **hour**, **the** **Sun**’s **rate** **of** **movement** **across** **the** **sky**. Apparently, **the** **birds** **were** **assuming** **that** **the** “**Sun**” **they** **saw** **was** **moving** **at** **that** **rate**. **When** **the** **real** **Sun** **was** visible, **however**, **the** **birds** maintained **a** **constant** **direction** **as** **it** **moved** **across** **the** **sky**. **In** **other** **words**, **they** **were** **able** **to** **compensate** **for** **the** **Sun**’s **movement**. **This** **meant** **that** **some** **sort** **of** biological **clock** **was** **operating**–**and** **a** **very** **precise** **clock** **at** **that**.

**What** **about** **birds** **that** migrate **at** **night**? **Perhaps** **they** navigate **by** **the** **night** **sky**. **To** **test** **the** **idea**, **caged** **night**-migrating **birds** **were** **placed** **on** **the** **floor** **of** **a** planetarium **during** **their** migratory **period**. **A** planetarium **is** essentially **a** theater **with** **a** domelike **ceiling** **onto** **which** **a** **night** **sky** **can** **be** **projected** **for** **any** **night** **of** **the** **year**. **When** **the** planetarium **sky** **matched** **the** **sky** **outside**, **the** **birds** fluttered **in** **the** **direction** **of** **their** **normal** migration. **But** **when** **the** dome **was** rotated, **the** **birds** **changed** **their** **direction** **to** **match** **the** **artificial** **sky**. **The** **results** **clearly** indicated **that** **the** **birds** **were** orienting **according to** **the** **stars**.

**There** **is** **accumulating** **evidence** indicating **that** **birds** navigate **by** **using** **a** **wide** **variety** **of** environmental cues. **Other** **areas** **under** investigation **include** magnetism, landmarks, coastlines, sonar, **and** **even** **smells**. **The** **studies** **are** complicated **by** **the** **fact** **that** **the** **data** **are** **sometimes** **contradictory** **and** **the** mechanisms apparently **change** **from** **time** **to** **time**. Furthermore, **one** sensory **ability** may **back** **up** **another**.

count: 217

# Official 27-Passage 01 Crafts in the Ancient Near East

**Some** **of** **the** earliest **human** **civilizations** **arose** **in** **southern** Mesopotamia, **in** **what** **is** **now** **southern** Iraq, **in** **the** **fourth** millennium B.C.E. **In** **the** **second** **half** **of** **that** millennium, **in** **the** **south** **around** **the** **city** **of** Uruk, **there** **was** an enormous escalation **in** **the** **area** occupied **by** **permanent** **settlements**. **A** **large** **part** **of** **that** **increase** **took** **place** **in** Uruk **itself**, **which** **became** **a** **real** **urban** center **surrounded** **by** **a** **set** **of** secondary **settlements**. **While** **population** estimates **are** notoriously unreliable, **scholars** **assume** **that** Uruk inhabitants **were** **able** **to** **support** **themselves** **from** **the** **agricultural** **production** **of** **the** **fields** **surrounding** **the** **city**, **which** **could** **be** **reached** **with** **a** **daily** commute. **But** Uruk’s dominant **size** **in** **the** **entire** region, **far** surpassing **that** **of** **other** **settlements**, indicates **that** **it** **was** **a** regional center **and** **a** **true** **city**. **Indeed**, **it** **was** **the** **first** **city** **in** **human** **history**.

**The** **vast** **majority** **of** **its** **population** **remained** **active** **in** **agriculture**, **even** **those** **people** **living** **within** **the** **city** **itself**. **But** **a** **small** segment **of** **the** **urban** **society** **started** **to** specialize **in** nonagricultural **tasks** **as** **a** **result** **of** **the** **city**’s **role** **as** **a** regional center. **Within** **the** productive sector, **there** **was** **a** **growth** **of** **a** **variety** **of** **specialist** craftspeople. **Early** **in** **the** Uruk **period**, **the** **use** **of** undecorated utilitarian pottery **was** **probably** **the** **result** **of** specialized **mass** **production**. **In** an **early** **fourth**-millennium **level** **of** **the** Eanna archaeological site **at** Uruk, **a** pottery **style** **appears** **that** **is** **most** **characteristic** **of** **this** **process**, **the** **so**-**called** beveled-rim **bowl**. **It** **is** **a** **rather** **shallow** **bowl** **that** **was** crudely **made** **in** **a** mold; hence, **in** **only** **a** **limited** **number** **of** **standard** **sizes**. **For** **some** **unknown** **reason**, **many** **were** discarded, **often** **still** intact, **and** **thousands** **have** **been** **found** **all** **over** **the** **Near** **East**. **The** beveled-rim **bowl** **is** **one** **of** **the** **most** **telling** diagnostic **finds** **for** identifying an Uruk-**period** site. **Of** **importance** **is** **the** **fact** **that** **it** **was** **produced** rapidly **in** **large** **amounts**, **most** **likely** **by** **specialists** **in** **a** **central** location.

**A** **variety** **of** documentation indicates **that** **certain** **goods**, **once** **made** **by** **a** **family** **member** **as** **one** **of** **many** **duties**, **were** **later** **made** **by** **skilled** artisans. **Certain** images depict **groups** **of** **people**, **most** **likely** **women**, involved **in** weaving textiles, an **activity** **we** **know** **from** **later** **third**-millennium **texts** **to** **have** **been** **vital** **in** **the** economy **and** **to** **have** **been** centrally administered. **Also**, **a** specialized **metal**-**producing** workshop may **have** **been** excavated **in** **a** **small** **area** **at** Uruk. **It** **contained** **a** **number** **of** **channels** **lined** **by** **a** sequence **of** **holes**, **about** 50 centimeters **deep**, **all** **showing** **burn** **marks** **and** **filled** **with** **ashes**. **This** **has** **been** interpreted **as** **the** **remains** **of** **a** workshop **where** molten **metal** **was** scooped **up** **from** **the** **channel** **and** **poured** **into** molds **in** **the** **holes**. **Some** **type** **of** **mass** **production** **by** **specialists** **was** involved **here**.

**Objects** **themselves** **suggest** **that** **they** **were** **the** **work** **of** **skilled** professionals. **In** **the** **late** Uruk **period** (3500–3100 B.C.E.), **there** **first** **appeared** **a** **type** **of** **object** **that** **remained** **characteristic** **for** Mesopotamia **throughout** **its** **entire** **history**: **the** cylinder **seal**. **This** **was** **a** **small** cylinder, **usually** **no** **more** **than** 3 centimeters **high** **and** 2 centimeters **in** diameter, **of** shell, **bone**, faience (**a** glassy **type** **of** stoneware), **or** **various** **types** **of** **stones**, **on** **which** **a** **scene** **was** **carved** **into** **the** **surface**. **When** **rolled** **over** **a** **soft** **material**—primarily **the** **clay** **of** bullae (**round** **seals**), **tablets**, **or** **clay** lumps **attached** **to** **boxes**, **jars**, **or** **door** bolts—**the** **scene** **would** **appear** **in** **relief** **a** **type** **of** **sculpture** **in** **which** **the** **subjects** **project** **from** **the** **background**, **easily** legible. **The** technological **knowledge** **needed** **to** **carve** **it** **was** **far** **superior** **to** **that** **for** **stamp** **seals**, **which** **had** **happened** **in** **the** **early** Neolithic **period** (**approximately** 10,000–5000 B.C.E.). **From** **the** **first** **appearance** **of** cylinder **seals**, **the** **carved** **scenes** **could** **be** highly elaborate **and** refined, indicating **the** **work** **of** **specialist** **stone**-cutters. Similarly, **the** **late** Uruk **period** **shows** **the** **first** monumental **art**, **relief**, **and** statuary **in** **the** **round**, **made** **with** **a** **degree** **of** mastery **that** **only** **a** professional **could** **have** **produced**.

count: 217

# Official 38-Passage 02 The Raccoons’s Success

Raccoons **have** **a** **vast** transcontinental distribution, **occurring** **throughout** **most** **of** **North** **America** **and** **Central** **America**. **They** **are** **found** **from** **southern** **Canada** **all** **the** **way** **to** Panama, **as** **well** **as** **on** **islands** **near** coastal **areas**. **They** **occur** **in** **each** **of** **the** 49 **states** **of** **the** continental **United** **States**. **Although** raccoons **are** **native** **only** **to** **the** **Western** Hemisphere, **they** **have** **been** successfully transplanted **to** **other** **parts** **of** **the** **globe**.

**Following** **a** **decline** **to** **a** relatively **low** **population** **level** **in** **the** 1930s, raccoons **began** **to** prosper **following** **their** 1943 breeding **season**. **A** **rapid** **population** surge **continued** **throughout** **the** 1940s, **and** **high** **numbers** **have** **been** sustained **ever** **since**. **By** **the** **late** 1980s, **the** **number** **of** raccoons **in** **North** **America** **was** estimated **to** **be** **at** **least** 15 **to** 20 **times** **the** **number** **that** **existed** **during** **the** 1930s. **By** **now**, **their** **numbers** **have** undoubtedly **grown** **even** **more**, **as** **they** **have** **continued** **to** **expand** **into** **new** habitats **where** **they** **were** **once** **either** **rare** **or** **absent**, **such** **as** sandy **prairies**, **deserts**, coastal marshes, **and** **mountains**. **Their** **spread** **throughout** **the** Rocky **Mountain** **West** **is** indicative **of** **the** **fast** **pace** **at** **which** **they** **can** **exploit** **new** **environments**. Despite significant **numbers** **being** **harvested** **and** **having** **suffered** occasional **declines**, typically **because** **of** **disease**, **the** raccoon **has** consistently maintained **high** **population** **levels**.

**Several** factors **explain** **the** raccoon’s dramatic **increase** **in** abundance **and** distribution. **First**, **their** **success** **has** **been** partially attributed **to** **the** **growth** **of** **cities**, **as** **they** **often** thrive **in** suburban **and** **even** **urban** settings. Furthermore, **they** **have** **been** **deliberately** **introduced** **throughout** **the** **continent**. **Within** **the** **United** **States**, **they** **are** commonly **taken** **from** **one** **area** **to** **another**, **both** legally **and** illegally, **to** restock **hunting** **areas** **and**, presumably, **because** **people** **simply** **want** **them** **to** **be** **part** **of** **their** **local** fauna. **Their** **appearance** **and** subsequent flourishing **in** Utah’s **Great** **Salt** **Lake** **valley** **within** **the** **last** 40 **years** **appears** **to** **be** **from** **such** an **introduction**. **As** an **example** **of** **the** **ease** **with** **which** transplanted individuals **can** **succeed**, raccoons **from** Indiana (midwestern **United** **States**) **have** reportedly **been** **able** **to** flourish **on** **islands** **off** **the** **coast** **of** Alaska.

**The** raccoon’s expansion **in** **various** **areas** may **also** **be** **due** **to** **the** **spread** **of** **agriculture**. Raccoons **have** **been** **able** **to** **exploit** **crops**, **especially** **corn** **but** **also** cereal **grains**, **which** **have** **become** dependable **food** sources **for** **them**. **The** expansion **of** **agriculture**, **however**, **does** **not** necessarily **lead** **to** **rapid** **increases** **in** **their** abundance. **Farming** **in** Kansas **and** **eastern** Colorado (**central** **and** **western** **United** **States**) proceeded rapidly **in** **the** 1870s **and** 1880s, **but** **this** **was** **about** 50 **years** **before** raccoons **started** **to** **spread** **out** **from** **their** **major** habitat, **the** **wooded** **river** bottomlands. **They** **have** **also** **expanded** **into** **many** **areas** **lacking** **any** **agriculture** **other** **than** grazing **and** **into** **places** **without** **forests** **or** **permanent** **streams**.

Prior **to** Europeans **settling** **and** **farming** **the** **Great** **Plains** regionA **vast** grassland region **in** **North** **America** extending **from** **central** **Canada** **south** **through** **the** **west** **central** **United** **States** **into** Texas, raccoons **probably** **were** **just** **found** **along** **its** **rivers** **and** **streams** **and** **in** **the** **wooded** **areas** **of** **its** southeastern **section**.

**With** **the** **possible** exception **of** **the** **southern** **part** **of** **the** **province** **of** Manitoba, **their** **absence** **was** notable **throughout** **Canada**. **They** **first** **became** **more** widely **distributed** **in** **the** **southern** **part** **of** Manitoba, **and** **by** **the** 1940s **were** **abundant** **throughout** **its** southeastern portion. **In** **the** 1950s **their** **population** **swelled** **in** **Canada**. **The** **control** **of** coyotes **in** **the** **prairie** region **in** **the** 1950s may **have** **been** **a** factor **in** raccoon expansion. **If** **their** **numbers** **are** sufficient, coyotes **might** **be** **able** **to** suppress raccoon **populations** (**though** **little** **direct** **evidence** **supports** **this** notion). **By** **the** 1960s **the** raccoon **had** **become** **a** **major** predator **of** **the** canvasback **ducks** **nesting** **in** southwestern Manitoba.

**The** extermination **of** **the** **wolf** **from** **most** **of** **the** contiguous **United** **States** may **have** **been** **a** critical factor **in** **the** raccoon’s expansion **and** numerical **increase**. **In** **the** eighteenth **century**, **when** **the** **wolf**’s **range** **included** **almost** **all** **of** **North** **America**, raccoons apparently **were** **abundant** **only** **in** **the** deciduous **forests** **of** **the** **East**, Gulf **Coast**, **and** **Great** **Lakes** regions, **though** **they** **also** extended **into** **the** **wooded** bottomlands **of** **the** Midwest’s **major** **rivers**. **In** **such** **areas**, **their** arboreal **habits** **and** **the** presence **of** hollow den **trees** **should** **have** **offered** **some** **protection** **from** **wolves** **and** **other** **large** predators. **Even** **though** raccoons may **not** **have** **been** **a** significant **part** **of** **their** **diet**, **wolves** surely **would** **have** **tried** **to** prey **on** **those** **exposed** **in** relatively treeless **areas**.

count: 216

# Official 37-Passage 03 Modern Architecture in the United States

**At** **the** **end** **of** **the** nineteenth **century**, **there** **were** basically **two** **kinds** **of** **buildings** **in** **the** **United** **States**. **On** **one** **hand** **were** **the** **buildings** **produced** **for** **the** **wealthy** **or** **for** civic **purposes**, **which** **tended** **to** echo **the** **architecture** **of** **the** **past** **and** **to** **use** **traditional** **styles** **of** ornamentation. **On** **the** **other** **hand** **were** purely utilitarian structures, **such** **as** **factories** **and** **grain** elevators, **which** **employed** **modern** **materials** **such** **as** **steel** girders **and** **plate** **glass** **in** an undisguised **and** unadorned **manner**. **Such** **buildings**, **however**, **were** **viewed** **in** **a** **category** **separate** **from** “**fine**” **architecture**, **and** **in** **fact** **were** **often** **designed** **by** **engineers** **and** builders **rather** **than** **architects**. **The** **development** **of** **modern** **architecture** **might** **in** **large** **part** **be** **seen** **as** an **adaptation** **of** **this** **sort** **of** functional **building** **and** **its** pervasive **application** **for** **daily** **use**. **Indeed**, **in** **his** influential **book**

**The** **fundamental** premise **of** **modern** **architecture** **was** **that** **the** **appearance** **of** **the** **building** **should** exhibit **the** **nature** **of** **its** **materials** **and** **forms** **of** **physical** **support**. **This** **often** **led** **to** **effects** **that** **looked** odd **from** **a** **traditional** standpoint **but** **that** **became** hallmarks **of** **modern** **architecture** **for** precisely **this** **reason**. **For** **example**, **in** **traditional** **architecture**, **stone** **or** **brick** **walls** **served** **a** structural **role**, **but** **in** **a** **steel**-**beam** **building** **the** **walls** **were** essentially **hung** **from** **the** internal skeleton **of** **steel** **beams**, **which** **meant** **that** **walls** **and** **corners** **no** longer **needed** **to** **be** **solid** **but** **could** **be** **opened** **up** **in** unexpected **ways**. **At** **the** Fagus **shoe** **factory** **in** **Germany**, **for** **example**, **German** **architect** Walter Gropius **placed** **glass** **walls** **in** **the** **corners**, effectively **breaking** **open** **the** **box** **of** **traditional** **architecture** **and** **creating** **a** **new** **sense** **of** **light** **and** openness. Similarly, **steel** **beams** **could** **be** **used** **to** **construct** **balconies** **that** **projected** **out** **from** **the** **building** **without** **any** **support** **beneath** **them**. **These** dramatic **balconies** quickly **became** **a** **signature** **of** **modern** **architects** **such** **as** Frank Lloyd Wright. Wright’s **most** dramatic residence, Fallingwater, **has** **balconies** **that** thrust **far** **out** **over** **a** **stream** **in** **a** **way** **that** **seems** **to** defy **gravity**.

**The** **ways** **in** **which** **new** **technology** **transformed** architectural **design** **are** dramatically illustrated **through** **the** **evolution** **of** **the** **high**-**rise** **office** **building**. After **ten** **or** **twelve** **stories**, masonry **construction** **reaches** **a** **maximum** **possible** **height**, **since** **it** **runs** **into** **difficulties** **of** compression **and** **of** inadequate lateral **strength** **to** combat **wind** shear. **Steel** **construction**, **on** **the** **other** **hand**, **can** **support** **a** **building** **of** 50 **or** 100 **stories** **without** **difficulty**. **Such** **buildings** **were** **so** **different** **from** **any** previous **form** **of** **architecture** **that** **they** quickly **acquired** **a** **new** **name**—**the** **skyscraper**.

**From** **the** standpoint **of** **real** estate developers, **the** **purpose** **of** **skyscrapers** **was** **to** **increase** rental **space** **in** **valuable** **urban** locations. **But** **to** **create** usable **high**-**rise** **buildings**, **a** **number** **of** **technical** **challenges** **needed** **to** **be** solved. **One** **problem** **was** **getting** **people** **to** **the** **upper** **floors**, **since** after **five** **or** **six** **stories** **it** **becomes** exhausting **to** **climb** **stairs**. Updated **and** electrified **versions** **of** **the** freight elevator **that** **had** **been** **introduced** **by** Elish Graves Otis **in** 1853 (**several** **decades** **before** **skyscraper** **construction**) solved **this** **problem**. **Another** issue **was** **fire** **safety**. **The** **metal** **supporting** **buildings** **became** **soft** **when** **exposed** **to** **fire** **and** collapsed relatively quickly. (**They** **could** melt **at** 2,700 Fahrenheit, whereas **major** **fires** **achieve** **temperatures** **of** 3,000 **degrees**). **However**, **when** **the** **metal** **is** encased **in** **fire**-retardant **materials**, **its** vulnerability **to** **fire** **is** **much** **decreased**. **In** Chicago, **a** **system** **was** **developed** **for** **surrounding** **the** **metal** **components** **with** hollow tiles **made** **from** **brick**-**like** terra-**cotta**. **Such** tiles **are** impervious **to** **fire**. **The** terra-**cotta** tiles **were** **used** **both** **to** encase **the** **supporting** **members** **and** **as** **flooring**. **A** structure **built** **with** **steel** **beams** **protected** **by** terra-**cotta** tiles **was** **still** **three** **times** lighter **than** **a** comparably **sized** **building** **that** **used** masonry **construction**, **so** **the** **weight** **of** **the** tiles **was** **not** **a** **problem**.

count: 216

# Official 50-Passage 01 American Railroads

**In** **the** **United** **States**, railroads spearheaded **the** **second** phase **of** **the** transportation **revolution** **by** overtaking **the** previous **importance** **of** **canals**. **The** mid-1800s **saw** **a** **great** expansion **of** **American** railroads. **The** **major** **cities** **east** **of** **the** Mississippi **River** **were** **linked** **by** **a** spiderweb **of** railroad **tracks**. Chicago’s **growth** illustrates **the** impact **of** **these** **rail** **links**. **In** 1849 Chicago **was** **a** **village** **of** **a** **few** **hundred** **people** **with** virtually **no** **rail** **service**. **By** 1860 **it** **had** **become** **a** **city** **of** 100,000, **served** **by** **eleven** railroads. **Farmers** **to** **the** **north** **and** **west** **of** Chicago **no** longer **had** **to** **ship** **their** **grain**, livestock, **and** dairy **products** **down** **the** Mississippi **River** **to** **New** Orleans; **they** **could** **now** **ship** **their** **products** directly **east**. Chicago supplanted **New** Orleans **as** **the** interior **of** **America**’s **main** commercial hub.

**The** **east**-**west** **rail** **lines** stimulated **the** **settlement** **and** **agricultural** **development** **of** **the** Midwest. **By** 1860 Illinois, Indiana, **and** Wisconsin **had** **replaced** Ohio, Pennsylvania, **and** **New York** York **as** **the** **leading** **wheat**-**growing** **states**. Enabling **farmers** **to** **speed** **their** **products** **to** **the** **East**, railroads **increased** **the** **value** **of** farmland **and** **promoted** additional **settlement**. **In** **turn**, **population** **growth** **in** **agricultural** **areas** triggered industrial **development** **in** **cities** **such** **as** Chicago, Davenport (Iowa), **and** Minneapolis, **for** **the** **new** **settlers** **needed** lumber **for** **fences** **and** **houses** **and** mills **to** grind **wheat** **into** **flour**.

Railroads **also** propelled **the** **growth** **of** **small** **towns** **along** **their** routes. **The** Illinois **Central** Railroad, **which** **had** **more** **track** **than** **any** **other** railroad **in** 1855, **made** **money** **not** **only** **from** **its** **traffic** **but** **also** **from** **real** estate speculation. **Purchasing** **land** **for** **stations** **along** **its** **path**, **the** Illinois **Central** **then** **laid** **out** **towns** **around** **the** **stations**. **The** selection **of** Manteno, Illinois, **as** **a** **stop** **of** **the** Illinois **Central**, **for** **example**, **transformed** **the** site **from** **a** **crossroads** **without** **a** **single** **house** **in** 1854 **into** **a** bustling **town** **of** **nearly** **a** **thousand** **in** 1860, replete **with** **hotels**, lumberyards, **grain** elevators, **and** gristmills. **By** **the** **Civil** **War** (1861–1865), **few** **thought** **of** **the** railroad-**linked** Midwest **as** **a** **frontier** region **or** **viewed** **its** inhabitants **as** **pioneers**.

**As** **the** **nation**’s **first** **big** **business**, **the** railroads **transformed** **the** **conduct** **of** **business**. **During** **the** **early** 1830s, railroads, **like** **canals**, **depended** **on** financial **aid** **from** **state** **governments**. **With** **the** onset **of** economic depression **in** **the** **late** 1830s, **however**, **state** **governments** scrapped overly ambitious railroad **projects**. **Convinced** **that** railroads **burdened** **them** **with** **high** **taxes** **and** blasted **hopes**, voters **turned** **against** **state** **aid**, **and** **in** **the** **early** 1840s, **several** **states** amended **their** **constitutions** **to** **bar** **state** funding **for** railroads **and** **canals**. **The** federal **government** **took** **up** **some** **of** **the** slack, **but** federal **aid** **did** **not** **provide** **a** **major** stimulus **to** railroads **before** 1860. **Rather**, **part** **of** **the** **burden** **of** **finance** **passed** **to** **city** **and** county **governments** **in** **agricultural** **areas** **that** **wanted** **to** **attract** railroads. **Such** municipal **governments**, **for** **example**, **often** **gave** railroads **rights**-**of**-**way**, grants **of** **land** **for** **stations**, **and** **public** funds.

**The** dramatic expansion **of** **the** railroad **network** **in** **the** 1850s, **however**, strained **the** **financing** capacity **of** **local** **governments** **and** **required** **a** **turn** **toward** **private** investment, **which** **had** **never** **been** **absent** **from** **the** **picture**. **Well** **aware** **of** **the** economic **benefits** **of** railroads, individuals **living** **near** **them** **had** **long** **purchased** railroad stock issued **by** **governments** **and** **had** directly **bought** stock **in** railroads, **often** **paying** **by** **contributing** **their** labor **to** **building** **the** railroads. **But** **the** **large** railroads **of** **the** 1850s **needed** **more** **capital** **than** **such** **small** investors **could** generate. **Gradually**, **the** center **of** railroad **financing** shifted **to** **New York** York **City**, **and** **in** **fact**, **it** **was** **the** railroad **boom** **of** **the** 1850s **that** **helped** **make** **Wall** **Street** **in** **New York** York **City** **the** **nation**’s greatest **capital** **market**. **The** stocks **of** **all** **the** **leading** railroads **were** **traded** **on** **the** **floor** **of** **the** **New York** York Stock **Exchange** **during** **the** 1850s. **In** **addition**, **the** **growth** **of** railroads **turned** **New York** York **City** **into** **the** center **of** **modern** investment **firms**. **The** investment **firms** **evaluated** **the** stock **of** railroads **in** **the** smaller **American** **cities** **and** **then** **found** purchasers **for** **these** stocks **in** **New York** York **City**, Philadelphia, **Paris**, **London**, Amsterdam, **and** Hamburg. **Controlling** **the** **flow** **of** funds **to** railroads, **the** investment bankers **began** **to** exert **influence** **over** **the** railroads’ internal **affairs** **by** supervising administrative reorganizations **in** **times** **of** **trouble**.

count: 215

# Official 25-Passage 02 The Decline of Venetian Shipping

**In** **the** **late** thirteenth **century**, **northern** **Italian** **cities** **such** **as** Genoa, Florence, **and** Venice **began** an economic resurgence **that** **made** **them** **into** **the** **most** **important** economic centers **of** **Europe**. **By** **the** seventeenth **century**, **however**, **other** **European** **powers** **had** **taken** **over**, **as** **the** **Italian** **cities** **lost** **much** **of** **their** economic **might**.

**This** **decline** **can** **be** **seen** **clearly** **in** **the** **changes** **that** **affected** Venetian **shipping** **and** **trade**. **First**, Venice’s intermediary **functions** **in** **the** Adriatic **Sea**, **where** **it** **had** dominated **the** **business** **of** **shipping** **for** **other** **parties**, **were** **lost** **to** **direct** **trading**. **In** **the** fifteenth **century** **there** **was** **little** **problem** recruiting **sailors** **to** **row** **the** galleys (**large** **ships** propelled **by** oars): guilds (**business** **associations**) **were** **required** **to** **provide** rowers, **and** **through** **a** **draft** **system** **free** **citizens** **served** compulsorily **when** **called** **for**. **In** **the** **early** **sixteenth** **century** **the** shortage **of** rowers **was** **not** **serious** **because** **the** **demand** **for** galleys **was** **limited** **by** **a** **move** **to** **round** **ships** (**round**-hulled **ships** **with** **more** cargo **space**), **which** **required** fewer rowers. **But** **the** shortage **of** **crews** **proved** **to** **be** **a** greater **and** greater **problem**, despite continuous **appeal** **to** Venice’s **tradition** **of** maritime greatness. **Even** **though** **sailors**’ **wages** **doubled** **among** **the** **northern** **Italian** **cities** **from** 1550 **to** 1590, **this** **did** **not** elicit an **increased** **supply**.

**The** **problem** **in** **shipping** extended **to** **the** Arsenale, Venice’s **huge** **and** **powerful** shipyard. Timber **ran** **short**, **and** **it** **was** **necessary** **to** procure **it** **from** farther **and** farther **away**. **In** **ancient** Roman **times**, **the** **Italian** peninsula **had** **great** **forests** **of** fir **preferred** **for** warships, **but** scarcity **was** **apparent** **as** **early** **as** **the** **early** fourteenth **century**. Arsenale **officers** **first** **brought** timber **from** **the** foothills **of** **the** Alps, **then** **from** **north** **toward** Trieste, **and** finally **from** **across** **the** Adriatic. **Private** shipbuilders **were** **required** **to** **buy** **their** oak **abroad**. **As** **the** **costs** **of** shipbuilding **rose**, Venice clung **to** **its** outdated **standards** **while** **the** Dutch **were** innovating **in** lighter **and** **more** **easily** **handled** **ships**.

**The** **step** **from** **buying** **foreign** timber **to** **buying** **foreign** **ships** **was** **regarded** **as** **a** **short** **one**, **especially** **when** complaints **were** **heard** **in** **the** **latter** **sixteenth** **century** **that** **the** **standards** **and** **traditions** **of** **the** Arsenale **were** **running** **down**. **Work** **was** stretched **out** **and** **done** poorly. Older **workers** **had** **been** **allowed** **to** **stop** **work** **a** **half** **hour** **before** **the** **regular** **time**, **and** **in** 1601 younger **workers** **left** **with** **them**. **Merchants** complained **that** **the** **privileges** **reserved** **for** Venetian-**built** **and** -**owned** **ships** **were** **first** extended **to** **those** Venetians **who** **bought** **ships** **from** **abroad** **and** **then** **to** **foreign**-**built** **and** -**owned** vessels. Historian Frederic Lane **observes** **that** after **the** **loss** **of** **ships** **in** **battle** **in** **the** **late** **sixteenth** **century**, **the** shipbuilding **industry** **no** longer **had** **the** capacity **to** **recover** **that** **it** **had** displayed **at** **the** **start** **of** **the** **century**.

**The** **conventional** **explanation** **for** **the** **loss** **of** Venetian dominance **in** **trade** **is** **the** establishment **of** **the** Portuguese **direct** **sea** route **to** **the** **East**, **replacing** **the** overland **Silk** **Road** **from** **the** **Black** **Sea** **and** **the** highly profitable **Indian** **Ocean**-caravan-**eastern** Mediterranean route **to** Venice. **The** Portuguese Vasco da Gama’s **voyage** **around** **southern** **Africa** **to** **India** **took** **place** **at** **the** **end** **of** **the** fifteenth **century**, **and** **by** 1502 **the** trans-Arabian caravan route **had** **been** **cut** **off** **by** **political** **unrest**.

**The** Venetian Council finally **allowed** **round** **ships** **to** **enter** **the** **trade** **that** **was** previously **reserved** **for** **merchant** galleys, **thus** **reducing** **transport** **costs** **by** **one** **third**. **Prices** **of** spices **delivered** **by** **ship** **from** **the** **eastern** Mediterranean **came** **to** **equal** **those** **of** spices **transported** **by** Portuguese vessels, **but** **the** **increase** **in** **quantity** **with** **both** routes **in** **operation** **drove** **the** **price** **far** **down**. **Gradually**, Venice’s **role** **as** **a** **storage** **and** distribution center **for** spices **and** **silk**, dyes, **cotton**, **and** **gold** decayed, **and** **by** **the** **early** seventeenth **century** Venice **had** **lost** **its** monopoly **in** **markets** **such** **as** **France** **and** **southern** **Germany**.

Venetian **shipping** **had** **started** **to** **decline** **from** **about** 1530—**before** **the** **entry** **into** **the** Mediterranean **of** **large** volumes **of** Dutch **and** **British** **shipping**—**and** **was** **clearly** outclassed **by** **the** **end** **of** **the** **century**. **A** **contemporary** **of** Shakespeare (1564–1616) **observed** **that** **the** productivity **of** **Italian** **shipping** **had** **declined**, **compared** **with** **that** **of** **the British**, **because** **of** conservatism **and** **loss** **of** expertise. Moreover, **Italian** **sailors** **were** **deserting** **and** emigrating, **and** **captains**, **no** longer recruited **from** **the** **ranks** **of** **nobles**, **were** **weak** **on** navigation.

count: 215

# Official 18-Passage 01 Industrialization in the Netherlands and Scandinavia

**While** **some** **European** **countries**, **such** **as** **England** **and** **Germany**, **began** **to** industrialize **in** **the** eighteenth **century**, **the** Netherlands **and** **the** Scandinavian **countries** **of** Denmark, Norway, **and** Sweden **developed** **later**. **All** **four** **of** **these** **countries** lagged considerably **behind** **in** **the** **early** nineteenth **century**. **However**, **they** industrialized rapidly **in** **the** **second** **half** **of** **the** **century**, **especially** **in** **the** **last** **two** **or** **three** **decades**. **In** **view** **of** **their** **later** **start** **and** **their** **lack** **of** **coal**—undoubtedly **the** **main** **reason** **they** **were** **not** **among** **the** **early** industrializers—**it** **is** **important** **to** **understand** **the** sources **of** **their** **success**.

**All** **had** **small** **populations**. **At** **the** **beginning** **of** **the** nineteenth **century**, Denmark **and** Norway **had** fewer **than** 1 **million** **people**, **while** Sweden **and** **the** Netherlands **had** fewer **than** 2.5 **million** inhabitants. **All** exhibited moderate **growth** **rates** **in** **the** **course** **of** **the** **century** (Denmark **the** highest **and** Sweden **the** lowest), **but** **all** **more** **than** **doubled** **in** **population** **by** 1900. Density varied greatly. **The** Netherlands **had** **one** **of** **the** highest **population** densities **in** **Europe**, whereas Norway **and** Sweden **had** **the** lowest. Denmark **was** **in** **between** **but** closer **to** **the** Netherlands.

**Considering** **human** **capital** **as** **a** **characteristic** **of** **the** **population**, **however**, **all** **four** **countries** **were** **advantaged** **by** **the** **large** **percentages** **of** **their** **populations** **who** **could** **read** **and** **write**. **In** **both** 1850 **and** 1914, **the** Scandinavian **countries** **had** **the** highest literacy **rates** **in** **Europe**, **or** **in** **the** **world**, **and** **the** Netherlands **was** **well** **above** **the** **European** **average**. **This** **fact** **was** **of** enormous **value** **in** **helping** **the** **national** economies **find** **their** niches **in** **the** evolving currents **of** **the** **international** economy.

Location **was** an **important** factor **for** **all** **four** **countries**. **All** **had** **immediate** **access** **to** **the** **sea**, **and** **this** **had** **important** implications **for** **a** significant **international** resource, **fish**, **as** **well** **as** **for** **cheap** **transport**, **merchant** marines, **and** **the** shipbuilding **industry**. **Each** **took** **advantage** **of** **these** opportunities **in** **its** **own** **way**. **The** **people** **of** **the** Netherlands, **with** **a** **long** **tradition** **of** fisheries **and** mercantile **shipping**, **had** **difficulty** **in** **developing** **good** harbors **suitable** **for** steamships; **eventually** **they** **did** **so** **at** Rotterdam **and** Amsterdam, **with** exceptional **results** **for** transit **trade** **with** **Germany** **and** **central** **Europe** **and** **for** **the** **processing** **of** overseas foodstuffs **and** **raw** **materials** (**sugar**, **tobacco**, **chocolate**, **grain**, **and** **eventually** **oil**). Denmark **also** **had** an **admirable** commercial **history**, particularly **with** **respect** **to** **traffic** **through** **the** **Sound** (**the** **strait** **separating** Denmark **and** Sweden). **In** 1857, **in** **return** **for** **a** payment **of** 63 **million** kronor **from** **other** commercial **nations**, Denmark **abolished** **the** **Sound** toll **dues**, **the** **fees** **it** **had** **collected** **since** 1497 **for** **the** **use** **of** **the** **Sound**. **This**, **along** **with** **other** **policy** shifts **toward** **free** **trade**, **resulted** **in** **a** significant **increase** **in** **traffic** **through** **the** **Sound** **and** **in** **the** **port** **of** Copenhagen.

**The** **political** **institutions** **of** **the** **four** **countries** posed **no** significant **barriers** **to** industrialization **or** economic **growth**. **The** nineteenth **century** **passed** relatively peacefully **for** **these** **countries**, **with** progressive democratization **taking** **place** **in** **all** **of** **them**. **They** **were** reasonably **well** **governed**, **without** notable corruption **or** grandiose **state** **projects**, **although** **in** **all** **of** **them** **the** **government** **gave** **some** **aid** **to** **railways**, **and** **in** Sweden **the** **state** **built** **the** **main** **lines**. **As** **small** **countries** dependent **on** **foreign** **markets**, **they** **followed** **a** liberal **trade** **policy** **in** **the** **main**, **though** **a** protectionist **movement** **developed** **in** Sweden. **In** Denmark **and** Sweden **agricultural** **reforms** **took** **place** **gradually** **from** **the** **late** eighteenth **century** **through** **the** **first** **half** **of** **the** nineteenth, **resulting** **in** **a** **new** **class** **of** **peasant** landowners **with** **a** definite **market** orientation.

**The** **key** factor **in** **the** **success** **of** **these** **countries** (**along** **with** **high** literacy, **which** **contributed** **to** **it**) **was** **their** **ability** **to** **adapt** **to** **the** **international** **division** **of** labor **determined** **by** **the** **early** industrializers **and** **to** stake **out** **areas** **of** specialization **in** **international** **markets** **for** **which** **they** **were** **especially** **well** **suited**. **This** **meant** **a** **great** dependence **on** **international** commerce, **which** **had** notorious fluctuations; **but** **it** **also** **meant** **high** **returns** **to** **those** factors **of** **production** **that** **were** **fortunate** **enough** **to** **be** **well** **placed** **in** **times** **of** prosperity. **In** Sweden **exports** **accounted** **for** 18 **percent** **of** **the** **national** **income** **in** 1870, **and** **in** 1913, 22 **percent** **of** **a** **much** larger **national** **income**. **In** **the** **early** **twentieth** **century**, Denmark **exported** 63 **percent** **of** **its** **agricultural** **production**: **butter**, **pork** **products**, **and** **eggs**. **It** **exported** 80 **percent** **of** **its** **butter**, **almost** **all**

**to** **Great** **Britain**, **where** **it** **accounted** **for** 40 **percent** **of** **British** **butter** **imports**.

count: 215

# Official 37-Passage 01 Thales and the Milesians

**While** **many** **other** observers **and** thinkers **had** **laid** **the** groundwork **for** **science**, Thales (circa 624 B.C.E.–ca 547 B.C.E.), **the** **best** **known** **of** **the** earliest **Greek** philosophers, **made** **the** **first** **steps** **toward** **a** **new**, **more** objective **approach** **to** **finding** **out** **about** **the** **world**. **He** posed **a** **very** **basic** **question**: “**What** **is** **the** **world** **made** **of**?” **Many** **others** **had** **asked** **the** **same** **question** **before** **him**, **but** Thales **based** **his** **answer** strictly **on** **what** **he** **had** **observed** **and** **what** **he** **could** **reason** **out**—**not** **on** imaginative **stories** **about** **the** **gods** **or** **the** supernatural. **He** proposed **water** **as** **the** **single** substance **from** **which** **everything** **in** **the** **world** **was** **made** **and** **developed** **a** **model** **of** **the** **universe** **with** **Earth** **as** **a** **flat** **disk** **floating** **in** **water**.

**Like** **most** **of** **the** **great** **Greek** philosophers, Thales **had** an **influence** **on** **others** **around** **him**. **His** **two** **best**-**known** followers, **though** **there** **were** undoubtedly **others** **who** **attained** **less** renown, **were** Anaximander **and** Anaximenes. **Both** **were** **also** **from** Miletus (located **on** **the** **southern** **coast** **of** **present**-**day** **Turkey**) **and** **so**, **like** Thales, **were** **members** **of** **the** Milesian **School**. **Much** **more** **is** **known** **about** Anaximander **than** **about** Anaximenes, **probably** **because** Anaximander, **who** **was** **born** sometime **around** 610 BCE, ambitiously **attempted** **to** **write** **a** comprehensive **history** **of** **the** **universe**. **As** **would** **later** **happen** **between** **another** **teacher**-**student** **pair** **of** philosophers, Plato **and** Aristotle, Anaximander **disagreed** **with** **his** **teacher** despite **his** **respect** **for** **him**. **He** **doubted** **that** **the** **world** **and** **all** **its** **contents** **could** **be** **made** **of** **water** **and** proposed **instead** **a** formless **and** unobservable substance **he** **called** “apeiron” **that** **was** **the** source **of** **all** **matter**.

Anaximander’s **most** **important** **contributions**, **though**, **were** **in** **other** **areas**. **Although** **he** **did** **not** **accept** **that** **water** **was** **the** prime element, **he** **did** **believe** **that** **all** **life** originated **in** **the** **sea**, **and** **he** **was** **thus** **one** **of** **the** **first** **to** conceive **of** **this** **important** **idea**. Anaximander **is** **credited** **with** **drawing** **up** **the** **first** **world** **map** **of** **the** Greeks **and** **also** **with** recognizing **that** **Earth**’s **surface** **was** curved. **He** **believed**, **though**, **that** **the** **shape** **of** **Earth** **was** **that** **of** **a** cylinder **rather** **than** **the** sphere **that** **later** **Greek** philosophers **would** conjecture. Anaximander, **observing** **the** motions **of** **the** **heavens** **around** **the** polestar, **was** **probably** **the** **first** **of** **the** **Greek** philosophers **to** **picture** **the** **sky** **as** **a** sphere completely **surrounding** **Earth**—an **idea** **that**, elaborated **upon** **later**, **would** prevail **until** **the** advent **of** **the** **Scientific** **Revolution** **in** **the** seventeenth **century**.

**Unfortunately**, **most** **of** Anaximander’s **written** **history** **of** **the** **universe** **was** **lost**, **and** **only** **a** **few** fragments **survive** **today**. **Little** **is** **known** **about** **his** **other** **ideas**. **Unfortunately**, **too**, **most** **of** **the** **written** **work** **of** Anaximenes, **who** may **have** **been** Anaximander’s **pupil**, **has** **also** **been** **lost**. **All** **we** **can** **say** **for** **certain** **about** Anaximenes, **who** **was** **probably** **born** **around** 560 BCE, **is** **that** **following** **in** **the** **tradition** **of** Anaximander, **he** **also** **disagreed** **with** **his** mentor. **The** **world**, **according to** Anaximenes, **was** **not** composed **of** **either** **water** **or** apeiron, **but** **air** **itself** **was** **the** **fundamental** element **of** **the** **universe**. Compressed, **it** **became** **water** **and** **earth**, **and** **when** rarefied **or** **thinned** **out**, **it** **heated** **up** **to** **become** **fire**. Anaximenes may **have** **also** **been** **the** **first** **to** **study** **rainbows** **and** speculate **upon** **their** **natural** **rather** **than** supernatural **cause**.

**With** **the** **door** **opened** **by** Thales **and** **the** **other** **early** philosophers **of** Miletus, **Greek** thinkers **began** **to** speculate **about** **the** **nature** **of** **the** **universe**. **This** **exciting** **burst** **of** intellectual **activity** **was** **for** **the** **most** **part** purely creative. **The** Greeks, **from** Thales **to** Plato **and** Aristotle, **were** philosophers **and** **not** **scientists** **in** **today**’s **sense**. **It** **is** **possible** **for** **anyone** **to** **create** “**ideas**” **about** **the** **nature** **and** structure **of** **the** **universe**, **for** instance, **and** **many** **times** **these** **ideas** **can** **be** **so** **consistent** **and** elaborately structured, **or** **just** **so** apparently **obvious**, **that** **they** **can** **be** persuasive **to** **many** **people**. **A** **scientific** **theory** **about** **the** **universe**, **however**, **demands** **much** **more** **than** **the** **various** observations **and** analogies **that** **were** woven **together** **to** **form** **systems** **of** **reasoning**, carefully **constructed** **as** **they** **were**, **that** **would** **eventually** culminate **in** Aristotle’s **model** **of** **the** **world** **and** **the** **universe**. **Without** experimentation **and** objective, critical **testing** **of** **their** **theories**, **the** **best** **these** thinkers **could** **hope** **to** **achieve** **was** **some** internally **consistent** speculation **that** **covered** **all** **the** **bases** **and** **satisfied** **the** **demands** **of** **reason**.

count: 215

# Official 21-Passage 01 Geothermal Energy

**Earth**’s internal **heat**, **fueled** **by** radioactivity, **provides** **the** energy **for** **plate** tectonics **and** continental drift, **mountain** **building**, **and** **earthquakes**. **It** **can** **also** **be** harnessed **to** **drive** **electric** generators **and** **heat** **homes**. Geothermal energy **becomes** **available** **in** **a** **practical** **form** **when** **underground** **heat** **is** transferred **by** **water** **that** **is** **heated** **as** **it** **passes** **through** **a** subsurface region **of** **hot** **rocks** (**a** **heat** reservoir) **that** may **be** **hundreds** **or** **thousands** **of** **feet** **deep**. **The** **water** **is** **usually** naturally **occurring** groundwater **that** seeps **down** **along** fractures **in** **the** **rock**; **less** typically, **the** **water** **is** artificially **introduced** **by** **being** **pumped** **down** **from** **the** **surface**. **The** **water** **is** **brought** **to** **the** **surface**, **as** **a** **liquid** **or** **steam**, **through** **holes** **drilled** **for** **the** **purpose**.

**By** **far** **the** **most** **abundant** **form** **of** geothermal energy **occurs** **at** **the** relatively **low** **temperatures** **of** 80° **to** 180° **centigrade**. **Water** **circulated** **through** **heat** reservoirs **in** **this** **temperature** **range** **is** **able** **to** extract **enough** **heat** **to** **warm** residential, commercial, **and** industrial **spaces**. **More** **than** 20,000 **apartments** **in** **France** **are** **now** **heated** **by** **warm** **underground** **water** **drawn** **from** **a** **heat** reservoir **in** **a** geologic structure **near** **Paris** **called** **the** **Paris** **Basin**. **Iceland** **sits** **on** **a** volcanic structure **known** **as** **the** Mid-**Atlantic** Ridge. Reykjavik, **the** **capital** **of** **Iceland**, **is** entirely **heated** **by** geothermal energy derived **from** volcanic **heat**.

Geothermal reservoirs **with** **temperatures** **above** 180° **centigrade** **are** **useful** **for** generating **electricity**. **They** **occur** primarily **in** regions **of** **recent** volcanic **activity** **as** **hot**, **dry** **rock**; **natural** **hot** **water**; **or** **natural** **steam**. **The** **latter** **two** sources **are** **limited** **to** **those** **few** **areas** **where** **surface** **water** seeps **down** **through** **underground** **faults** **or** fractures **to** **reach** **deep** **rocks** **heated** **by** **the** **recent** **activity** **of** molten **rock** **material**. **The** **world**’s largest **supply** **of** **natural** **steam** **occurs** **at** **The** Geysers, 120 kilometers **north** **of** San Francisco, California. **In** **the** 1990s **enough** **electricity** **to** **meet** **about** **half** **the** **needs** **of** San Francisco **was** **being** generated **there**. **This** facility **was** **then** **in** **its** **third** **decade** **of** **production** **and** **was** **beginning** **to** **show** **signs** **of** **decline**, **perhaps** **because** **of** **over** **development**. **By** **the** **late** 1990s **some** 70 geothermal **electric**-generating **plants** **were** **in** **operation** **in** California, Utah, Nevada, **and** Hawaii, generating **enough** **power** **to** **supply** **about** **a** **million** **people**. **Eighteen** **countries** **now** generate **electricity** **using** geothermal **heat**.

Extracting **heat** **from** **very** **hot**, **dry** **rocks** **presents** **a** **more** **difficult** **problem**: **the** **rocks** must **be** fractured **to** **permit** **the** circulation **of** **water**, **and** **the** **water** must **be** **provided** artificially. **The** **rocks** **are** fractured **by** **water** **pumped** **down** **at** **very** **high** **pressures**. **Experiments** **are** **under** **way** **to** **develop** **technologies** **for** **exploiting** **this** resource.

**Like** **most** **other** energy sources, geothermal energy **presents** **some** environmental **problems**. **The** **surface** **of** **the** **ground** **can** **sink** **if** **hot** groundwater **is** **withdrawn** **without** **being** **replaced**. **In** **addition**, **water** **heated** geothermally **can** **contain** **salts** **and** toxic **materials** dissolved **from** **the** **hot** **rock**. **These** **waters** **present** **a** disposal **problem** **if** **they** **are** **not** **returned** **to** **the** **ground** **from** **which** **they** **were** **removed**.

**The** **contribution** **of** geothermal energy **to** **the** **world**’s energy **future** **is** **difficult** **to** estimate. Geothermal energy **is** **in** **a** **sense** **not** renewable, **because** **in** **most** **cases** **the** **heat** **would** **be** **drawn** **out** **of** **a** reservoir **much** **more** rapidly **than** **it** **would** **be** **replaced** **by** **the** **very** **slow** geological **processes** **by** **which** **heat** **flows** **through** **solid** **rock** **into** **a** **heat** reservoir. **However**, **in** **many** **places** (**for** **example**, California, Hawaii, **the** Philippines, **Japan**, **Mexico**, **the** rift **valleys** **of** **Africa**) **the** resource **is** potentially **so** **large** **that** **its** **future** **will** **depend** **on** **the** economics **of** **production**. **At** **present**, **we** **can** **make** efficient **use** **of** **only** naturally **occurring** **hot** **water** **or** **steam** **deposits**. **Although** **the** **potential** **is** enormous, **it** **is** **likely** **that** **in** **the** **near** **future** geothermal energy **can** **make** **important** **local** **contributions** **only** **where** **the** resource **is** **close** **to** **the** **user** **and** **the** economics **are** favorable, **as** **they** **are** **in** California, **New Zealand** Zealand, **and** **Iceland**. Geothermal energy **probably** **will** **not** **make** **large**-scale **contributions** **to** **the** **world** energy **budget** **until** **well** **into** **the** **twenty-first** **century**, **if** **ever**.

count: 215

# Official 02-Passage 03 Early Cinema

**The** **cinema** **did** **not** emerge **as** **a** **form** **of** **mass** consumption **until** **its** **technology** evolved **from** **the** **initial** “peepshow” **format** **to** **the** **point** **where** images **were** **projected** **on** **a** **screen** **in** **a** darkened theater. **In** **the** peepshow **format**, **a** **film** **was** **viewed** **through** **a** **small** **opening** **in** **a** **machine** **that** **was** **created** **for** **that** **purpose**. Thomas Edison’s peepshow device, **the** Kinetoscope, **was** **introduced** **to** **the** **public** **in** 1894.  **It** **was** **designed** **for** **use** **in** Kinetoscope parlors, **or** arcades, **which** **contained** **only** **a** **few** individual **machines** **and** **permitted** **only** **one** **customer** **to** **view** **a** **short**, 50-**foot** **film** **at** **any** **one** **time**.  **The** **first** Kinetoscope parlors **contained** **five** **machines**.  **For** **the** **price** **of** 25 **cents** (**or** 5 **cents** **per** **machine**), **customers** **moved** **from** **machine** **to** **machine** **to** **watch** **five** **different** **films** (**or**, **in** **the** **case** **of** **famous** prizefights, successive **rounds** **of** **a** **single** **fight**).

**These** Kinetoscope arcades **were** **modeled** **on** phonograph parlors, **which** **had** **proven** **successful** **for** Edison **several** **years** earlier.  **In** **the** phonograph parlors, **customers** **listened** **to** recordings **through** individual **ear** **tubes**, **moving** **from** **one** **machine** **to** **the** **next** **to** **hear** **different** **recorded** **speeches** **or** **pieces** **of** **music**.  **The** Kinetoscope parlors **functioned** **in** **a** **similar** **way**.  Edison **was** **more** **interested** **in** **the** **sale** **of** Kinetoscopes (**for** roughly $1,000 apiece) **to** **these** parlors **than** **in** **the** **films** **that** **would** **be** **run** **in** **them** (**which** **cost** **approximately** $10 **to** $15 **each**).  **He** **refused** **to** **develop** projection **technology**, **reasoning** **that** **if** **he** **made** **and** **sold** projectors, **then** exhibitors **would** **purchase** **only** **one** **machine** - **a** projector -**from** **him** **instead** **of** **several**.

Exhibitors, **however**, **wanted** **to** maximize **their** **profits**, **which** **they** **could** **do** **more** readily **by** **projecting** **a** **handful** **of** **films** **to** **hundreds** **of** **customers** **at** **a** **time** (**rather** **than** **one** **at** **a** **time**) **and** **by** **charging** 25 **to** 50 **cents** **admission**.  **About** **a** **year** after **the** **opening** **of** **the** **first** Kinetoscope parlor **in** 1894, showmen **such** **as** Louis **and** Auguste Lumière, Thomas Armat **and** Charles Francis Jenkins, **and** Orville **and** Woodville Latham (**with** **the** **assistance** **of** Edison’s **former** **assistant**, William Dickson) **perfected** projection devices.  **These** **early** projection devices **were** **used** **in** vaudeville theaters, legitimate theaters, **local** **town** **halls**, makeshift storefront theaters, fairgrounds, **and** **amusement** **parks** **to** **show** **films** **to** **a** **mass** **audience**.

**With** **the** advent **of** projection **in** 1895-1896, motion **pictures** **became** **the** ultimate **form** **of** **mass** consumption.  Previously, **large** **audiences** **had** **viewed** spectacles **at** **the** theater, **where** vaudeville, **popular** dramas, **musical** **and** minstrel **shows**, **classical** **plays**, **lectures**, **and** **slide**-**and**-**lantern** **shows** **had** **been** **presented** **to** **several** **hundred** spectators **at** **a** **time**.  **But** **the** **movies** **differed** significantly **from** **these** **other** **forms** **of** **entertainment**, **which** **depended** **on** **either** **live** **performance** **or** (**in** **the** **case** **of** **the** **slide**-**and**-**lantern** **shows**) **the** **active** involvement **of** **a** **master** **of** **ceremonies** **who** assembled **the** **final** program.

**Although** **early** exhibitors regularly **accompanied** **movies** **with** **live** **acts**, **the** substance **of** **the** **movies** **themselves** **is** **mass**-**produced**, prerecorded **material** **that** **can** **easily** **be** reproduced **by** theaters **with** **little** **or** **no** **active** participation **by** **the** exhibitor.  **Even** **though** **early** exhibitors **shaped** **their** **film** programs **by** editing **them** **together** **in** **whichever** **way** **they** **thought** **would** **be** **most** **attractive** **to** **audiences** **or** **by** **accompanying** **them** **with** **lectures**, **their** creative **control** **remained** **limited**.  **What** **audiences** **came** **to** **see** **was** **the** technological marvel **of** **the** **movies**; **the** lifelike reproduction **of** **the** commonplace motion **of** **trains**, **of** **waves** **striking** **the** **shore**, **and** **of** **people** **walking** **in** **the** **street**; **and** **the** **magic** **made** **possible** **by** **trick** photography **and** **the** manipulation **of** **the** **camera**.

**With** **the** advent **of** projection, **the** **viewer**’s **relationship** **with** **the** image **was** **no** longer **private**, **as** **it** **had** **been** **with** earlier peepshow devices **such** **as** **the** Kinetoscope **and** **the** Mutoscope, **which** **was** **a** **similar** **machine** **that** reproduced motion **by** **means** **of** successive images **on** individual photographic **cards** **instead** **of** **on** strips **of** celluloid. **It** suddenly **became** **public** – an **experience** **that** **the** **viewer** **shared** **with** **dozens**, **scores**, **and** **even** **hundreds** **of** **others**.  **At** **the** **same** **time**, **the** image **that** **the** spectator **looked** **at** **expanded** **from** **the** minuscule peepshow **dimensions** **of** 1 **or** 2 **inches** (**in** **height**) **to** **the** **life**-**size** proportions **of** 6 **or** 9 **feet**.

count: 214

# Official 08-Passage 03 Running Water on Mars

Photographic **evidence** **suggests** **that** **liquid** **water** **once** **existed** **in** **great** **quantity** **on** **the** **surface** **of** Mars. **Two** **types** **of** **flow** features **are** **seen**: runoff **channels** **and** outflow **channels**. Runoff **channels** **are** **found** **in** **the** **southern** highlands. **These** **flow** features **are** extensive **systems**—**sometimes** **hundreds** **of** kilometers **in** **total** **length**—**of** interconnecting, **twisting** **channels** **that** **seem** **to** merge **into** larger, wider **channels**. **They** **bear** **a** **strong** resemblance **to** **river** **systems** **on** **Earth**, **and** geologists **think** **that** **they** **are** **dried**-**up** **beds** **of** **long**-**gone** **rivers** **that** **once** **carried** **rainfall** **on** Mars **from** **the** **mountains** **down** **into** **the** **valleys**. Runoff **channels** **on** Mars **speak** **of** **a** **time** 4 **billion** **years** **ago** (**the** **age** **of** **the** Martian highlands), **when** **the** **atmosphere** **was** thicker, **the** **surface** warmer, **and** **liquid** **water** **widespread**.

Outflow **channels** **are** **probably** relics **of** catastrophic **flooding** **on** Mars **long** **ago**. **They** **appear** **only** **in** equatorial regions **and** generally **do** **not** **form** extensive interconnected **networks**. **Instead**, **they** **are** **probably** **the** **paths** **taken** **by** **huge** volumes **of** **water** draining **from** **the** **southern** highlands **into** **the** **northern** **plains**. **The** onrushing **water** **arising** **from** **these** **flash** **floods** **likely** **also** **formed** **the** odd teardrop-**shaped** “**islands**” (**resembling** **the** miniature **versions** **seen** **in** **the** **wet** **sand** **of** **our** **beaches** **at** **low** tide)  **that** **have** **been** **found** **on** **the** **plains** **close** **to** **the** **ends** **of** **the** outflow **channels**. **Judging** **from** **the** width **and** **depth** **of** **the** **channels**, **the** **flow** **rates** must **have** **been** **truly** enormous—**perhaps** **as** **much** **as** **a** **hundred** **times** greater **than** **the** 105 **tons** **per** **second** **carried** **by** **the** **great** Amazon **river**. **Flooding** **shaped** **the** outflow **channels** **approximately** 3 **billion** **years** **ago**, **about** **the** **same** **time** **as** **the** **northern** volcanic **plains** **formed**.

**Some** **scientists** speculate **that** Mars may **have** **enjoyed** an extended **early** **period** **during** **which** **rivers**, **lakes**, **and** **perhaps** **even** **oceans** adorned **its** **surface**. **A** 2003 Mars Global Surveyor image **shows** **what** mission **specialists** **think** may **be** **a** delta—**a** **fan**-**shaped** **network** **of** **channels** **and** sediments **where** **a** **river** **once** **flowed** **into** **a** larger body **of** **water**, **in** **this** **case** **a** **lake** **filling** **a** crater **in** **the** **southern** highlands.**Other** researchers **go** **even** further, **suggesting** **that** **the** **data** **provide** **evidence** **for** **large** **open** expanses **of** **water** **on** **the** **early** Martian **surface**. **A** **computer**-generated **view** **of** **the** Martian **north** polar region **shows** **the** extent **of** **what** may **have** **been** an **ancient** **ocean** **covering** **much** **of** **the** **northern** lowlands. **The** Hellas **Basin**, **which** **measures** **some** 3,000 kilometers **across** **and** **has** **a** **floor** **that** **lies** **nearly** 9 kilometers **below** **the** **basin**’s rim, **is** **another** **candidate** **for** an **ancient** Martian **sea**.

**These** **ideas** **remain** **controversial**. Proponents **point** **to** features **such** **as** **the** terraced “**beaches**” **shown** **in** **one** image, **which** **could** conceivably **have** **been** **left** **behind** **as** **a** **lake** **or** **ocean** evaporated **and** **the** shoreline receded. **But** detractors maintain **that** **the** terraces **could** **also** **have** **been** **created** **by** geological **activity**, **perhaps** **related** **to** **the** geologic **forces** **that** depressed **the** **Northern** Hemisphere **far** **below** **the** **level** **of** **the** **south**, **in** **which** **case** **they** **have** **nothing** **whatever** **to** **do** **with** Martian **water**. Furthermore, Mars Global Surveyor **data** released **in** 2003 **seem** **to** indicate **that** **the** Martian **surface** **contains** **too** **few** carbonate **rock** layers—layers **containing** compounds **of** **carbon** **and** **oxygen**—**that** **should** **have** **been** **formed** **in** abundance **in** an **ancient** **ocean**. **Their** **absence** **supports** **the** **picture** **of** **a** **cold**, **dry** Mars **that** **never** **experienced** **the** extended **mild** **period** **required** **to** **form** **lakes** **and** **oceans**. **However**, **more** **recent** **data** imply **that** **at** **least** **some** **parts** **of** **the** **planet** **did** **in** **fact** **experience** **long** **periods** **in** **the** **past** **during** **which** **liquid** **water** **existed** **on** **the** **surface**.

**Aside** **from** **some** **small**-scale gullies (**channels**) **found** **since** 2000, **which** **are** inconclusive, **astronomers** **have** **no** **direct** **evidence** **for** **liquid** **water** **anywhere** **on** **the** **surface** **of** Mars **today**, **and** **the** **amount** **of** **water** vapor **in** **the** Martian **atmosphere** **is** **tiny**. **Yet** **even** **setting** **aside** **the** unproven hints **of** **ancient** **oceans**, **the** extent **of** **the** outflow **channels** **suggests** **that** **a** **huge** **total** volume **of** **water** **existed** **on** Mars **in** **the** **past**. **Where** **did** **all** **the** **water** **go**? **The** **answer** may **be** **that** virtually **all** **the** **water** **on** Mars **is** **now** **locked** **in** **the** permafrost layer **under** **the** **surface**, **with** **more** **contained** **in** **the** **planet**’s polar **caps**.

count: 214

# Official 41-Passage 02 Trade and Early State Formation

Bartering **was** **a** **basic** **trade** mechanism **for** **many** **thousands** **of** **years**; **often** sporadic **and** **usually** **based** **on** notions **of** reciprocity, **it** involved **the** mutual **exchange** **of** commodities **or** **objects** **between** individuals **or** **groups**. Redistribution **of** **these** **goods** **through** **society** **lay** **in** **the** **hands** **of** **chiefs**, **religious** **leaders**, **or** kin **groups**. **Such** redistribution **was** **a** **basic** element **in** chiefdoms. **The** **change** **from** redistribution **to** formal **trade**—**often** **based** **on** regulated commerce **that** **perhaps** involved **fixed** **prices** **and** **even** **currency**—**was** closely **tied** **to** **growing** **political** **and** **social** complexity **and** hence **to** **the** **development** **of** **the** **state** **in** **the** **ancient** **world**.

**In** **the** 1970s, **a** **number** **of** archaeologists **gave** **trade** **a** **primary** **role** **in** **the** **rise** **of** **ancient** **states**. **British** archaeologist Colin Renfrew attributed **the** dramatic **flowering** **of** **the** Minoan **civilization** **on** Crete **and** **through** **the** Aegean **to** intensified **trading** contacts **and** **to** **the** impact **of** olive **and** vine cultivation **on** **local** communities. **As** **agricultural** economies **became** **more** diversified **and** **local** **food** **supplies** **could** **be** **purchased** **both** locally **and** **over** longer **distances**, **a** **far**-**reaching** economic interdependence **resulted**.**Eventually**, **this** **led** **to** redistribution **systems** **for** luxuries **and** **basic** commodities, **systems** **that** **were** organized **and** **controlled** **by** Minoan **rulers** **from** **their** **palaces**. **As** **time** **went** **on**, **the** **self**-sufficiency **of** communities **was** **replaced** **by** mutual dependence. **Interest** **in** **long**-**distance** **trade** **brought** **about** **some** cultural homogeneity **from** **trade** **and** **gift** **exchange**, **and** **perhaps** **even** **led** **to** piracy. **Thus**, intensified **trade** **and** interaction, **and** **the** **flowering** **of** **specialist** crafts, **in** **a** **complex** **process** **of** positive feedback, **led** **to** **much** **more** **complex** **societies** **based** **on** **palaces**, **which** **were** **the** economic hubs **of** **a** **new** Minoan **civilization**.

Renfrew’s **model** **made** **some** **assumptions** **that** **are** **now** **discounted**. **For** **example**, **he** **argued** **that** **the** **introduction** **of** domesticated vines **and** olives **allowed** **a** substantial expansion **of** **land** **under** cultivation **and** **helped** **to** **power** **the** emergence **of** **complex** **society**. **Many** archaeologists **and** paleobotanists **now** **question** **this** **view**, **pointing** **out** **that** **the** **available** **evidence** **for** cultivated vines **and** olives **suggests** **that** **they** **were** **present** **only** **in** **the** **later** Bronze **Age**. **Trade**, nevertheless, **was** **probably** **one** **of** **many** variables **that** **led** **to** **the** emergence **of** **palace** economies **in** Minoan Crete.

**American** archaeologist William Rathje **developed** **a** hypothesis **that** **considered** an explosion **in** **long**-**distance** **exchange** **a** **fundamental** **cause** **of** Mayan **civilization** **in** Mesoamerica. **He** **suggested** **that** **the** lowland Mayan **environment** **was** deficient **in** **many** **vital** resources, **among** **them** obsidian, **salt**, **stone** **for** grinding maize, **and** **many** luxury **materials**. **All** **these** **could** **be** **obtained** **from** **the** **nearby** highlands, **from** **the** **Valley** **of** **Mexico**, **and** **from** **other** regions, **if** **the** **necessary** **trading** **networks** **came** **into** **being**.**Such** **connections**, **and** **the** **trading** expeditions **to** maintain **them**, **could** **not** **be** organized **by** individual **villages**. **The** Maya **lived** **in** **a** relatively **uniform** **environment**, **where** **every** community **suffered** **from** **the** **same** resource deficiencies. **Thus**, **argued** Rathje, **long**-**distance** **trade** **networks** **were** organized **through** **local** ceremonial centers **and** **their** **leaders**. **In** **time**, **this** **organization** **became** **a** **state**, **and** **knowledge** **of** **its** **functioning** **was** exportable, **as** **were** pottery, tropical **bird** **feathers**, specialized **stone** **materials**, **and** **other** **local** commodities.

Rathje’s hypothesis **probably** **explains** **part** **of** **the** **complex** **process** **of** Mayan **state** formation, **but** **it** **suffers** **from** **the** objection **that** **suitable** **alternative** **raw** **materials** **can** **be** **found** **in** **the** lowlands. **It** **could** **be**, **too**, **that** warfare **became** **a** competitive response **to** **population** **growth** **and** **to** **the** **increasing** scarcity **of** prime **agricultural** **land**, **and** **that** **it** **played** an **important** **role** **in** **the** emergence **of** **the** Mayan **states**.

**Now** **that** **we** **know** **much** **more** **about** **ancient** **exchange** **and** commerce, **we** **know** **that**, **because** **no** **one** **aspect** **of** **trade** **was** an overriding **cause** **of** cultural **change** **or** **evolution** **in** commercial **practices**, **trade** **can** **never** **be** **looked** **on** **as** **a** unifying factor **or** **as** **a** **primary** **agent** **of** **ancient** **civilization**. **Many** **ever**-**changing** variables **affected** **ancient** **trade**, **among** **them** **the** **demand** **for** **goods**. **There** **were** **also** **the** logistics **of** transportation, **the** extent **of** **the** **trading** **network**, **and** **the** **social** **and** **political** **environment**. Intricate **market** **networks** **channeled** **supplies** **along** **well**-defined routes. **Authorities** **at** **both** **ends** **might** regulate **the** **profits** **fed** **back** **to** **the** source, **providing** **the** incentive **for** further transactions. **There** may **or** may **not** **have** **been** **a** **market** **organization**. Extensive **long**-**distance** **trade** **was** **a** **consequence** **rather** **than** **a** **cause** **of** **complex** **societies**.

count: 213

# Official 24-Passage 01 Lake Water

**Where** **does** **the** **water** **in** **a** **lake** **come** **from**, **and** **how** **does** **water** **leave** **it**? **Water** **enters** **a** **lake** **from** inflowing **rivers**, **from** underwater seeps **and** **springs**, **from** overland **flow** **off** **the** **surrounding** **land**, **and** **from** **rain** **falling** directly **on** **the** **lake** **surface**. **Water** **leaves** **a** **lake** **via** outflowing **rivers**, **by** soaking **into** **the** **bed** **of** **the** **lake**, **and** **by** evaporation. **So** **much** **is** **obvious**.

**The** **questions** **become** **more** complicated **when** **actual** volumes **of** **water** **are** **considered**: **how** **much** **water** **enters** **and** **leaves** **by** **each** route? **Discovering** **the** inputs **and** **outputs** **of** **rivers** **is** **a** **matter** **of** **measuring** **the** discharges **of** **every** inflowing **and** outflowing **stream** **and** **river**. **Then** **exchanges** **with** **the** **atmosphere** **are** **calculated** **by** **finding** **the** **difference** **between** **the** **gains** **from** **rain**, **as** **measured** (**rather** roughly) **by** **rain** gauges, **and** **the** **losses** **by** evaporation, **measured** **with** **models** **that** **correct** **for** **the** **other** sources **of** **water** **loss**. **For** **the** **majority** **of** **lakes**, **certainly** **those** **surrounded** **by** **forests**, input **from** overland **flow** **is** **too** **small** **to** **have** **a** noticeable **effect**. **Changes** **in** **lake** **level** **not** **explained** **by** **river** **flows** **plus** **exchanges** **with** **the** **atmosphere** must **be** **due** **to** **the** **net** **difference** **between** **what** seeps **into** **the** **lake** **from** **the** groundwater **and** **what** **leaks** **into** **the** groundwater. **Note** **the** **word** “**net**”: **measuring** **the** **actual** **amounts** **of** groundwater seepage **into** **the** **lake** **and** **out** **of** **the** **lake** **is** **a** **much** **more** complicated **matter** **than** **merely** inferring **their** **difference**.

**Once** **all** **this** **information** **has** **been** **gathered**, **it** **becomes** **possible** **to** **judge** **whether** **a** **lake**’s **flow** **is** mainly **due** **to** **its** **surface** inputs **and** **outputs** **or** **to** **its** **underground** inputs **and** **outputs**. **If** **the** **former** **are** greater, **the** **lake** **is** **a** **surface**-**water**-dominated **lake**; **if** **the** **latter**, **it** **is** **a** seepage-dominated **lake**. Occasionally, **common** **sense** **tells** **you** **which** **of** **these** **two** **possibilities** **applies**. **For** **example**, **a** **pond** **in** **hilly** **country** **that** maintains **a** **steady** **water** **level** **all** **through** **a** **dry** **summer** **in** spite **of** **having** **no** **streams** **flowing** **into** **it** must obviously **be** seepage dominated. Conversely, **a** **pond** **with** **a** **stream** **flowing** **in** **one** **end** **and** **out** **the** **other**, **which** **dries** **up** **when** **the** **stream** **dries** **up**, **is** **clearly** **surface** **water** dominated.

**By** **whatever** **means**, **a** **lake** **is** constantly **gaining** **water** **and** **losing** **water**: **its** **water** **does** **not** **just** **sit** **there**, **or**, anyway, **not** **for** **long**. **This** **raises** **the** **matter** **of** **a** **lake**’s residence **time**. **The** residence **time** **is** **the** **average** **length** **of** **time** **that** **any** **particular** molecule **of** **water** **remains** **in** **the** **lake**, **and** **it** **is** **calculated** **by** **dividing** **the** volume **of** **water** **in** **the** **lake** **by** **the** **rate** **at** **which** **water** **leaves** **the** **lake**. **The** residence **time** **is** an **average**; **the** **time** **spent** **in** **the** **lake** **by** **a** **given** molecule (**if** **we** **could** **follow** **its** fate) **would** **depend** **on** **the** route **it** **took**: **it** **might** **flow** **through** **as** **part** **of** **the** fastest, **most** **direct** current, **or** **it** **might** **circle** **in** **a** backwater **for** an indefinitely **long** **time**.

Residence **times** vary enormously. **They** **range** **from** **a** **few** **days** **for** **small** **lakes** **up** **to** **several** **hundred** **years** **for** **large** **ones**; **Lake** Tahoe, **in** California, **has** **a** residence **time** **of** 700 **years**. **The** residence **times** **for** **the** **Great** **Lakes** **of** **North** **America**, namely, **Lakes** **Superior**, Michigan, Huron, Erie, **and** Ontario, **are**, respectively, 190, 100, 22, 2.5, **and** 6 **years**. **Lake** Erie’s **is** **the** lowest: **although** **its** **area** **is** larger **than** **Lake** Ontario’s, **its** volume **is** **less** **than** **one**-**third** **as** **great** **because** **it** **is** **so** **shallow**—**less** **then** 20 meters **on** **average**.

**A** **given** **lake**’s residence **time** **is** **by** **no** **means** **a** **fixed** **quantity**. **It** **depends** **on** **the** **rate** **at** **which** **water** **enters** **the** **lake**, **and** **that** **depends** **on** **the** **rainfall** **and** **the** evaporation **rate**. Climatic **change** (**the** **result** **of** global **warming**?) **is** dramatically **affecting** **the** residence **times** **of** **some** **lakes** **in** northwestern Ontario, **Canada**. **In** **the** **period** 1970 **to** 1986, **rainfall** **in** **the** **area** **decreased** **from** 1,000 millimeters **to** 650 millimeters **per** annum, **while** **above**-**average** **temperatures** **speeded** **up** **the** evapotranspiration **rate** (**the** **rate** **at** **which** **water** **is** **lost** **to** **the** **atmosphere** **through** evaporation **and** **the** **processes** **of** **plant** **life**). **The** **result** **has** **been** **that** **the** residence **time** **of** **one** **of** **the** **lakes** **increased** **from** 5 **to** 18 **years** **during** **the** **study** **period**. **The** **slowing** **down** **of** **water** renewal **leads** **to** **a** **chain** **of** further **consequences**; **it** **causes** dissolved **chemicals** **to** **become** increasingly **concentrated**, **and** **this**, **in** **turn**, **has** **a** **marked** **effect** **on** **all** **living** **things** **he** **lake**.

count: 213

# Official 15-Passage 02 Mass Extinctions

**Cases** **in** **which** **many** species **become** extinct **within** **a** geologically **short** **interval** **of** **time** **are** **called** **mass** extinctions. **There** **was** **one** **such** **event** **at** **the** **end** **of** **the** Cretaceous **period** (**around** 70 **million** **years** **ago**). **There** **was** **another**, **even** larger, **mass** extinction **at** **the** **end** **of** **the** Permian **period** (**around** 250 **million** **years** **ago**). **The** Permian **event** **has** **attracted** **much** **less** **attention** **than** **other** **mass** extinctions **because** mostly unfamiliar species perished **at** **that** **time**.

**The** fossil **record** **shows** **at** **least** **five** **mass** extinctions **in** **which** **many** **families** **of** marine organisms **died** **out**. **The** **rates** **of** extinction **happening** **today** **are** **as** **great** **as** **the** **rates** **during** **these** **mass** extinctions. **Many** **scientists** **have** **therefore** **concluded** **that** **a** **sixth** **great** **mass** extinction **is** currently **in** **progress**.

**What** **could** **cause** **such** **high** **rates** **of** extinction? **There** **are** **several** hypotheses, **including** **warming** **or** **cooling** **of** **Earth**, **changes** **in** seasonal fluctuations **or** **ocean** currents, **and** **changing** **positions** **of** **the** **continents**. Biological hypotheses **include** ecological **changes** **brought** **about** **by** **the** **evolution** **of** cooperation **between** **insects** **and** **flowering** **plants** **or** **of** **bottom**-**feeding** predators **in** **the** **oceans**. **Some** **of** **the** proposed mechanisms **required** **a** **very** **brief** **period** **during** **which** **all** extinctions suddenly **took** **place**; **other** mechanisms **would** **be** **more** **likely** **to** **have** **taken** **place** **more** **gradually**, **over** an extended **period**, **or** **at** **different** **times** **on** **different** **continents**. **Some** hypotheses **fail** **to** **account** **for** simultaneous extinctions **on** **land** **and** **in** **the** **seas**. **Each** **mass** extinction may **have** **had** **a** **different** **cause**. **Evidence** **points** **to** **hunting** **by** **humans** **and** habitat destruction **as** **the** **likely** **causes** **for** **the** current **mass** extinction.

**American** paleontologists David Raup **and** John Sepkoski, **who** **have** **studied** extinction **rates** **in** **a** **number** **of** fossil **groups**, **suggest** **that** episodes **of** **increased** extinction **have** recurred periodically, **approximately** **every** 26 **million** **years** **since** **the** mid-Cretaceous **period**. **The** **late** Cretaceous extinction **of** **the** **dinosaurs** **and** ammonoids **was** **just** **one** **of** **the** **more** drastic **in** **a** **whole** series **of** **such** recurrent extinction episodes. **The** **possibility** **that** **mass** extinctions may recur periodically **has** **given** **rise** **to** **such** hypotheses **as** **that** **of** **a** **companion** **star** **with** **a** **long**-**period** **orbit** deflecting **other** bodies **from** **their** **normal** **orbits**, **making** **some** **of** **them** **fall** **to** **Earth** **as** meteors **and** **causing** **widespread** devastation **upon** impact.

**Of** **the** **various** hypotheses **attempting** **to** **account** **for** **the** **late** Cretaceous extinctions, **the** **one** **that** **has** **attracted** **the** **most** **attention** **in** **recent** **years** **is** **the** asteroid-impact hypothesis **first** **suggested** **by** Luis **and** Walter Alvarez. **According to** **this** hypothesis, **Earth** collided **with** an asteroid **with** an estimated diameter **of** 10 kilometers, **or** **with** **several** asteroids, **the** **combined** **mass** **of** **which** **was** comparable. **The** **force** **of** **collision** spewed **large** **amounts** **of** debris **into** **the** **atmosphere**, darkening **the** **skies** **for** **several** **years** **before** **the** finer particles **settled**. **The** **reduced** **level** **of** photosynthesis **led** **to** **a** massive **decline** **in** **plant** **life** **of** **all** **kinds**, **and** **this** **caused** massive **starvation** **first** **of** herbivores **and** subsequently **of** carnivores. **The** **mass** extinction **would** **have** **occurred** **very** suddenly **under** **this** hypothesis.

**One** **interesting** **test** **of** **the** Alvarez hypothesis **is** **based** **on** **the** presence **of** **the** **rare**-**earth** element iridium (Ir). **Earth**’s crust **contains** **very** **little** **of** **this** element, **but** **most** asteroids **contain** **a** **lot** **more**. Debris **thrown** **into** **the** **atmosphere** **by** an asteroid **collision** **would** presumably **contain** **large** **amounts** **of** iridium, **and** atmospheric currents **would** **carry** **this** **material** **all** **over** **the** **globe**. **A** **search** **of** sedimentary **deposits** **that** span **the** **boundary** **between** **the** Cretaceous **and** Tertiary **periods** **shows** **that** **there** **is** **a** dramatic **increase** **in** **the** abundance **of** iridium briefly **and** precisely **at** **this** **boundary**. **This** iridium anomaly **offers** **strong** **support** **for** **the** Alvarez hypothesis **even** **though** **no** asteroid **itself** **has** **ever** **been** **recovered**.

An asteroid **of** **this** **size** **would** **be** **expected** **to** **leave** an immense crater, **even** **if** **the** asteroid **itself** **was** disintegrated **by** **the** impact. **The** intense **heat** **of** **the** impact **would** **produce** **heat**-**shocked** quartz **in** **many** **types** **of** **rock**. **Also**, **large** **blocks** **thrown** **aside** **by** **the** impact **would** **form** secondary craters **surrounding** **the** **main** crater. **To** **date**, **several** **such** secondary craters **have** **been** **found** **along** **Mexico**’s Yucatán Peninsula, **and** **heat**-**shocked** quartz **has** **been** **found** **both** **in** **Mexico** **and** **in** Haiti. **A** location **called** Chicxulub, **along** **the** Yucatán **coast**, **has** **been** **suggested** **as** **the** **primary** impact site.

count: 213

# Official 54-Passage 02 Overkill of the North American Megafauna

**Thousands** **of** **years** **ago**, **in** **North** **America**'s **past**, **all** **of** **its** megafauna—**large** mammals **such** **as** mammoths **and** giant **bears**—**disappeared**. **One** proposed **explanation** **for** **this** **event** **is** **that** **when** **the** **first** Americans migrated **over** **from** **Asia**, **they** **hunted** **the** megafauna **to** extinction.**These** **people**, **known** **as** **the** Clovis **society** after **a** site **where** **their** distinctive **spear** **points** **were** **first** **found**, **would** **have** **been** **able** **to** **use** **this** **food** source **to** **expand** **their** **population** **and** **fill** **the** **continent** rapidly.**Yet** **many** **scientists** **argue** **against** **this** 'Pleistocene overkill' hypothesis. **Modern** **humans** **have** **certainly** **been** capable **of** **such** drastic **effects** **on** **animals**, **but** **could** **ancient** **people** **with** **little** **more** **than** **stone** **spears** similarly **have** **caused** **the** extinction **of** numerous species **of** **animals**?**Thirty**-**five** genera **or** **groups** **of** species (**and** **many** individual species) **suffered** extinction **in** **North** **America** **around** 11,000 B.C., **soon** after **the** **appearance** **and** expansion **of** Paleo-lndians **throughout** **the** Americas (27 genera **disappeared** completely, **and** **another** 8 **became** locally extinct, **surviving** **only** **outside** **North** **America**).

**Although** **the** **climate** **changed** **at** **the** **end** **of** **the** Pleistocene, **warming** **trends** **had** **happened** **before**. **A** **period** **of** massive extinction **of** **large** mammals **like** **that** **seen** **about** 11,000 **years** **ago** **had** **not** **occurred** **during** **the** previous 400,000 **years**, despite **these** **changes**. **The** **only** apparently significant **difference** **in** **the** Americas 11,000 **years** **ago** **was** **the** presence **of** **human** **hunters** **of** **these** **large** mammals. **Was** **this** **coincidence** **or** **cause**-**and**-**effect**?

**We** **do** **not** **know**.Ecologist Paul S. Martin **has** **championed** **the** **model** **that** **associates** **the** extinction **of** **large** mammals **at** **the** **end** **of** **the** Pleistocene **with** **human** predation.**With** researcher J. E. Mosimann, **he** **has** co-**authored** **a** **work** **in** **which** **a** **computer** **model** **showed** **that** **in** **around** 300 **years**, **given** **the** **right** **conditions**, **a** **small** influx **of** **hunters** **into** **eastern** Beringia 12,000 **years** **ago** **could** **have** **spread** **across** **North** **America** **in** **a** **wave** **and** **wiped** **out** **game** **animals** **to** **feed** **their** burgeoning **population**.

**The** researchers **ran** **the** **model** **several** **ways**, **always** **beginning** **with** **a** **population** **of** 100 **humans** **in** Edmonton, **in** Alberta, **Canada**, **at** 11,500 **years** **ago**.**Assuming** **different** **initial** **North** **American** **big**-**game**-**animal** **populations** (75-150 **million** **animals**) **and** **different** **population** **growth** **rates** **for** **the** **human** **settlers** (0.65%-3.5%), **and** varying **kill** **rates**, Mosimann **and** Martin derived **figures** **of** **between** 279 **and** 1,157 **years** **from** **initial** contact **to** **big**-**game** extinction.

**Many** **scholars** **continue** **to** **support** **this** scenario.**For** **example**, geologist Larry Agenbroad **has** **mapped** **the** locations **of** **dated** Clovis sites **alongside** **the** distribution **of** **dated** sites **where** **the** **remains** **of** wooly mammoths **have** **been** **found** **in** **both** archaeological **and** purely paleontological contexts.**These** distributions **show** remarkable synchronicity (occurrence **at** **the** **same** **time**).

**There** **are**, **however**, **many** **problems** **with** **this** **model**.Significantly, **though** **a** **few** sites **are** **quite** impressive, **there** **really** **is** **very** **little** archaeological **evidence** **to** **support** **it**.**Writing** **in** 1982, Martin **himself** **admitted** **the** paucity **of** **evidence**;**for** **example**, **at** **that** **point**, **the** **remains** **of** **only** 38 individual mammoths **had** **been** **found** **at** Clovis sites. **In** **the** **years** **since**, **few** additional mammoths **have** **been** **added** **to** **the** **list**;**there** **are** **still** fewer **than** 20 Clovis sites **where** **the** **remains** **of** **one** **or** **more** mammoths **have** **been** **recovered**, **a** minuscule proportion **of** **the** **millions** **that** necessarily **would** **have** **had** **to** **have** **been** slaughtered **within** **the** overkill scenario.

**Though** Martin claims **the** **lack** **of** **evidence** actually **supports** **his** **model**—**the** **evidence** **is** sparse **because** **the** **spread** **of** **humans** **and** **the** extinction **of** **animals** **occurred** **so** quickly—**this** **argument** **seems** **weak**. **And** **how** **could** **we** **ever** disprove **it**?**As** archaeologist Donald Grayson **points** **out**, **in** **other** **cases** **where** extinction **resulted** **from** **the** **quick** **spread** **of** **human** **hunters**—**for** **example**, **the** extinction **of** **the** **moa**, **the** **large** flightless **bird** **of** **New Zealand** Zealand—archaeological **evidence** **in** **the** **form** **of** **remains** **is** **abundant**. Grayson **has** **also** **shown** **that** **the** **evidence** **is** **not** **so** **clear** **that** **all** **or** **even** **most** **of** **the** **large** herbivores **in** **late** Pleistocene **America** **became** extinct after **the** **appearance** **of** Clovis. **Of** **the** 35 extinct genera, **only** 8 **can** **be** confidently assigned an extinction **date** **of** **between** 12,000 **and** 10,000 **years** **ago**.**Many** **of** **the** older genera, Grayson **argues**, may **have** succumbed **before** 12,000 B.C., **at** **least** **half** **a** **century** **before** **the** Clovis **showed** **up** **in** **the** **American** **West**.

count: 212

# Official 54-Passage 03 Elements of Life

**The** creation **of** **life** **requires** **a** **set** **of** **chemical** elements **for** **making** **the** **components** **of** **cells**. **Life** **on** **Earth** **uses** **about** 25 **of** **the** 92 naturally **occurring** **chemical** elements, **although** **just** 4 **of** **these** elements—**oxygen**, **carbon**, **hydrogen**, **and** nitrogen—**make** **up** **about** 96 **percent** **of** **the** **mass** **of** **living** organisms. **Thus**, **a** **first** **requirement** **for** **life** **might** **be** **the** presence **of** **most** **or** **all** **of** **the** elements **used** **by** **life**.

    Interestingly, **this** **requirement** **can** **probably** **be** **met** **by** **almost** **any** **world**. **Scientists** **have** **determined** **that** **all** **chemical** elements **in** **the** **universe** **besides** **hydrogen** **and** helium (**and** **a** trace **amount** **of** lithium) **were** **produced** **by** **stars**. **These** **are** **known** **as** **heavy** elements **because** **they** **are** heavier **than** **hydrogen** **and** helium. **Although** **all** **of** **these** **heavy** elements **are** **quite** **rare** **compared** **to** **hydrogen** **and** helium, **they** **are** **found** **just** **about** **everywhere**.

**Heavy** elements **are** continually **being** manufactured **by** **stars** **and** released **into** **space** **by** stellar **deaths**, **so** **their** **amount** **compared** **to** **hydrogen** **and** helium **gradually** **rises** **with** **time**. **Heavy** elements **make** **up** **about** 2 **percent** **of** **the** **chemical** **content** (**by** **mass**) **of** **our** **solar** **system**; **the** **other** 98 **percent** **is** **hydrogen** **and** helium. **In** **some** **very** **old** **star** **systems**, **which** **formed** **before** **many** **heavy** elements **were** **produced**, **the** **heavy**-element **share** may **be** **less** **than** 0.1 **percent**. Nevertheless, **every** **star** **system** **studied** **has** **at** **least** **some** **amount** **of** **all** **the** elements **used** **by** **life**. Moreover, **when** planetesimals—**small**, **solid** **objects** **formed** **in** **the** **early** **solar** **system** **that** may **accumulate** **to** **become** **planets**—condense **within** **a** **forming** **star** **system**, **they** **are** inevitably **made** **from** **heavy** elements **because** **the** **more** **common** **hydrogen** **and** helium **remain** gaseous. **Thus**, planetesimals **everywhere** **should** **contain** **the** elements **needed** **for** **life**, **which** **means** **that** **objects** **built** **from** planetesimals—**planets**, **moons**, asteroids, **and** comets—**also** **contain** **these** elements. **The** **nature** **of** **solar**-**system** formation **explains** **why** **Earth** **contains** **all** **the** elements **needed** **for** **life**, **and** **it** **is** **why** **we** **expect** **these** elements **to** **be** **present** **on** **other** **worlds** **throughout** **our** **solar** **system**, galaxy, **and** **universe**.

**Note** **that** **this** **argument** **does** **not** **change**, **even** **if** **we** **allow** **for** **life** **very** **different** **from** **life** **on** **Earth**. **Life** **on** **Earth** **is** **carbon** **based**, **and** **most** biologists **believe** **that** **life** elsewhere **is** **likely** **to** **be** **carbon** **based** **as** **well**. **However**, **we** cannot absolutely **rule** **out** **the** **possibility** **of** **life** **with** **another** **chemical** **basis**, **such** **as** silicon **or** nitrogen. **The** **set** **of** elements (**or** **their** **relative** proportions) **used** **by** **life** **based** **on** **some** **other** element **might** **be** somewhat **different** **from** **that** **used** **by** **carbon**-**based** **life** **on** **Earth**. **But** **the** elements **are** **still** **products** **of** **stars** **and** **would** **still** **be** **present** **in** planetesimals **everywhere**. **No** **matter** **what** **kinds** **of** **life** **we** **are** **looking** **for**, **we** **are** **likely** **to** **find** **the** **necessary** elements **on** **almost** **every** **planet**, **moon**, asteroid, **and** comet **in** **the** **universe**.

**A** somewhat stricter **requirement** **is** **the** presence **of** **these** elements **in** molecules **that** **can** **be** **used** **as** **ready**-**made** **building** **blocks** **for** **life**, **just** **as** **early** **Earth** **probably** **had** an organic **soup** **of** amino **acids** **and** **other** **complex** molecules. **Earth**’s organic molecules **likely** **came** **from** **some** combination **of** **three** sources: **chemical** reactions **in** **the** **atmosphere**, **chemical** reactions **near** **deep**-**sea** vents **in** **the** **oceans**, **and** molecules **carried** **to** **Earth** **by** asteroids **and** comets. **The** **first** **two** sources **can** **occur** **only** **on** **worlds** **with** **atmospheres** **or** **oceans**, respectively. **But** **the** **third** source **should** **have** **brought** **similar** molecules **to** **nearly** **all** **worlds** **in** **our** **solar** **system**.

**Studies** **of** meteorites **and** comets **suggest** **that** organic molecules **are** **widespread** **among** **both** asteroids **and** comets. **Because** **each** body **in** **the** **solar** **system** **was** repeatedly **struck** **by** asteroids **and** comets **during** **the** **period** **known** **as** **the** **heavy** bombardment (**about** 4 **billion** **years** **ago**), **each** body **should** **have** **received** **at** **least** **some** organic molecules. **However**, **these** molecules **tend** **to** **be** **destroyed** **by** **solar** **radiation** **on** **surfaces** unprotected **by** **atmospheres**. Moreover, **while** **these** molecules **might** **stay** intact **beneath** **the** **surface** (**as** **they** evidently **do** **on** asteroids **and** comets), **they** **probably** cannot **react** **with** **each** **other** **unless** **some** **kind** **of** **liquid** **or** **gas** **is** **available** **to** **move** **them** **about**. **Thus**, **if** **we** **limit** **our** **search** **to** **worlds** **on** **which** organic molecules **are** **likely** **to** **be** involved **in** **chemical** reactions, **we** **can** **probably** **rule** **out** **any** **world** **that** **lacks** **both** an **atmosphere** **and** **a** **surface** **or** subsurface **liquid** **medium**, **such** **as** **water**.

count: 212

# Official 19-Passage 02 Succession, Climax, and Ecosystems

**In** **the** **late** nineteenth **century**, **ecology** **began** **to** **grow** **into** an **independent** **science** **from** **its** **roots** **in** **natural** **history** **and** **plant** **geography**. **The** emphasis **of** **this** **new** “community **ecology**” **was** **on** **the** **composition** **and** structure **of** communities **consisting** **of** **different** species. **In** **the** **early** **twentieth** **century**, **the** **American** ecologist Frederic Clements **pointed** **out** **that** **a** succession **of** **plant** communities **would** **develop** after **a** disturbance **such** **as** **a** volcanic eruption, **heavy** **flood**, **or** **forest** **fire**. An **abandoned** **field**, **for** instance, **will** **be** invaded successively **by** herbaceous **plants** (**plants** **with** **little** **or** **no** woody **tissue**), shrubs, **and** **trees**, **eventually** **becoming** **a** **forest**. **Light**-**loving** species **are** **always** **among** **the** **first** invaders, **while** **shade**-tolerant species **appear** **later** **in** **the** succession.

Clements **and** **other** **early** ecologists **saw** **almost** lawlike regularity **in** **the** **order** **of** succession, **but** **that** **has** **not** **been** substantiated. **A** **general** **trend** **can** **be** recognized, **but** **the** details **are** **usually** unpredictable. Succession **is** **influenced** **by** **many** factors: **the** **nature** **of** **the** **soil**, exposure **to** **sun** **and** **wind**, regularity **of** precipitation, **chance** colonizations, **and** **many** **other** **random** **processes**.

**The** **final** **stage** **of** **a** succession, **called** **the** climax **by** Clements **and** **early** ecologists, **is** likewise **not** predictable **or** **of** **uniform** **composition**. **There** **is** **usually** **a** **good** **deal** **of** turnover **in** species **composition**, **even** **in** **a** **mature** community. **The** **nature** **of** **the** climax **is** **influenced** **by** **the** **same** factors **that** **influenced** succession. Nevertheless, **mature** **natural** **environments** **are** **usually** **in** equilibrium. **They** **change** relatively **little** **through** **time** **unless** **the** **environment** **itself** **changes**.

**For** Clements, **the** climax **was** **a** “superorganism,” an organic entity. **Even** **some** **authors** **who** **accepted** **the** climax **concept** **rejected** Clements’ characterization **of** **it** **as** **a** superorganism, **and** **it** **is** **indeed** **a** misleading metaphor. An **ant** colony may **be** legitimately **called** **a** superorganism **because** **its** **communication** **system** **is** **so** highly organized **that** **the** colony **always** **works** **as** **a** **whole** **and** appropriately **according to** **the** **circumstances**. **But** **there** **is** **no** **evidence** **for** **such** an interacting communicative **network** **in** **a** climax **plant** formation. **Many** **authors** **prefer** **the** **term** “**association**” **to** **the** **term** “community” **in** **order** **to** **stress** **the** looseness **of** **the** interaction.

**Even** **less** **fortunate** **was** **the** **extension** **of** **this** **type** **of** **thinking** **to** **include** **animals** **as** **well** **as** **plants**. **This** **resulted** **in** **the** “biome,” **a** combination **of** coexisting flora **and** fauna. **Though** **it** **is** **true** **that** **many** **animals** **are** strictly **associated** **with** **certain** **plants**, **it** **is** misleading **to** **speak** **of** **a** “spruce-moose biome,” **for** **example**, **because** **there** **is** **no** internal cohesion **to** **their** **association** **as** **in** an organism. **The** spruce community **is** **not** substantially **affected** **by** **either** **the** presence **or** **absence** **of** moose. **Indeed**, **there** **are** **vast** **areas** **of** spruce **forest** **without** moose. **The** opposition **to** **the** Clementsian **concept** **of** **plant** **ecology** **was** initiated **by** Herbert Gleason, **soon** **joined** **by** **various** **other** ecologists. **Their** **major** **point** **was** **that** **the** distribution **of** **a** **given** species **was** **controlled** **by** **the** habitat **requirements** **of** **that** species **and** **that** **therefore** **the** vegetation **types** **were** **a** **simple** **consequence** **of** **the** **ecologies** **of** individual **plant** species.

**With** “climax,” “biome,” “superorganism,” **and** **various** **other** **technical** **terms** **for** **the** **association** **of** **animals** **and** **plants** **at** **a** **given** locality **being** criticized, **the** **term** “ecosystem” **was** **more** **and** **more** widely **adopted** **for** **the** **whole** **system** **of** **associated** organisms **together** **with** **the** **physical** factors **of** **their** **environment**. **Eventually**, **the** energy-**transforming** **role** **of** **such** **a** **system** **was** emphasized. Ecosystems **thus** involve **the** circulation, transformation, **and** accumulation **of** energy **and** **matter** **through** **the** **medium** **of** **living** **things** **and** **their** **activities**. **The** ecologist **is** **concerned** primarily **with** **the** **quantities** **of** **matter** **and** energy **that** **pass** **through** **a** **given** ecosystem, **and** **with** **the** **rates** **at** **which** **they** **do** **so**.

**Although** **the** ecosystem **concept** **was** **very** **popular** **in** **the** 1950s **and** 1960s, **it** **is** **no** longer **the** dominant paradigm. Gleason’s **arguments** **against** climax **and** biome **are** largely **valid** **against** ecosystems **as** **well**. Furthermore, **the** **number** **of** interactions **is** **so** **great** **that** **they** **are** **difficult** **to** **analyze**, **even** **with** **the** **help** **of** **large** **computers**. Finally, younger ecologists **have** **found** ecological **problems** involving behavior **and** **life**-**history** **adaptations** **more** **attractive** **than** **measuring** **physical** **constants**. Nevertheless, **one** **still** **speaks** **of** **the** ecosystem **when** **referring** **to** **a** **local** **association** **of** **animals** **and** **plants**, **usually** **without** **paying** **much** **attention** **to** **the** energy **aspects**.

count: 212

# Official 53-Passage 01 Evidence of the Earliest Writing

**Although** literacy **appeared** independently **in** **several** **parts** **of** **the** prehistoric **world**, **the** earliest **evidence** **of** **writing** **is** **the** cuneiform Sumerian script **on** **the** **clay** **tablets** **of** **ancient** Mesopotamia, **which**, archaeological **detective** **work** **has** revealed, **had** **its** **origins** **in** **the** **accounting** **practices** **of** commercial **activity**. Researchers demonstrated **that** preliterate **people**, **to** **keep** **track** **of** **the** **goods** **they** **produced** **and** **exchanged**, **created** **a** **system** **of** **accounting** **using** **clay** tokens **as** symbolic representations **of** **their** **products**. **Over** **many** **thousands** **of** **years**, **the** **symbols** evolved **through** **several** **stages** **of** abstraction **until** **they** **became** wedge-**shaped** (cuneiform) **signs** **on** **clay** **tablets**, recognizable **as** **writing**.

**The** original tokens (circa 8500 B.C.E.) **were** **three**-dimensional **solid** **shapes**—**tiny** spheres, cones, **disks**, **and** cylinders. **A** **debt** **of** **six** **units** **of** **grain** **and** **eight** **head** **of** livestock, **for** **example**, **might** **have** **been** **represented** **by** **six** conical **and** **eight** cylindrical tokens. **To** **keep** batches **of** tokens **together**, an innovation **was** **introduced** (circa 3250 B.C.E.) whereby **they** **were** **sealed** **inside** **clay** **envelopes** **that** **could** **be** **broken** **open** **and** **counted** **when** **it** **came** **time** **for** **a** **debt** **to** **be** repaid. **But** **because** **the** **contents** **of** **the** **envelopes** **could** **easily** **be** **forgotten**, **two**-dimensional representations **of** **the** **three**-dimensional tokens **were** **impressed** **into** **the** **surface** **of** **the** **envelopes** **before** **they** **were** **sealed**. **Eventually**, **having** **two** **sets** **of** equivalent **symbols**—**the** internal tokens **and** external markings—**came** **to** **seem** redundant, **so** **the** tokens **were** eliminated (circa 3250–3100 B.C.E.), **and** **only** **solid** **clay** **tablets** **with** **two**-dimensional **symbols** **were** retained. **Over** **time**, **the** **symbols** **became** **more** numerous, varied, **and** **abstract** **and** **came** **to** **represent** **more** **than** **trade** commodities, evolving **eventually** **into** cuneiform **writing**.

**The** **evolution** **of** **the** symbolism **is** **reflected** **in** **the** archaeological **record** **first** **of** **all** **by** **the** **increasing** complexity **of** **the** tokens **themselves**. **The** earliest tokens, **dating** **from** **about** 10,000 **to** 6,000 **years** **ago**, **were** **of** **only** **the** simplest geometric **shapes**. **But** **about** 3500 B.C.E., **more** **complex** tokens **came** **into** **common** usage, **including** **many** naturalistic **forms** **shaped** **like** miniature **tools**, **furniture**, **fruit**, **and** **humans**. **The** earlier, **plain** tokens **were** **counters** **for** **agricultural** **products**, whereas **the** **complex** **ones** **stood** **for** **finished** **products**, **such** **as** **bread**, **oil**, **perfume**, wool, **and** **rope**, **and** **for** items **produced** **in** workshops, **such** **as** **metal**, bracelets, **types** **of** **cloth**, **garments**, **mats**, **pieces** **of** **furniture**, **tools**, **and** **a** **variety** **of** **stone** **and** pottery vessels. **The** **signs** **marked** **on** **clay** **tablets** likewise evolved **from** **simple** wedges, **circles**, **ovals**, **and** **triangles** **based** **on** **the** **plain** tokens **to** pictographs derived **from** **the** **complex** tokens.

**Before** **this** **evidence** **came** **to** **light**, **the** **inventors** **of** **writing** **were** **assumed** **by** researchers **to** **have** **been** an intellectual elite. **Some**, **for** **example**, hypothesized **that** **writing** emerged **when** **members** **of** **the** priestly caste **agreed** **among** **themselves** **on** **written** **signs**. **But** **the** **association** **of** **the** **plain** tokens **with** **the** **first** **farmers** **and** **of** **the** **complex** tokens **with** **the** **first** artisans—**and** **the** **fact** **that** **the** token-**and**-**envelope** **accounting** **system** invariably **represented** **only** **small**-scale transactions—testifies **to** **the** relatively **modest** **social** **status** **of** **the** creators **of** **writing**.

**And** **not** **only** **of** literacy, **but** numeracy (**the** representation **of** quantitative **concepts**) **as** **well**. **The** **evidence** **of** **the** tokens **provides** further confirmation **that** **mathematics** originated **in** **people**’s **desire** **to** **keep** **records** **of** flocks **and** **other** **goods**. **Another** immensely significant **step** **occurred** **around** 3100 B.C. E., **when** Sumerian **accountants** extended **the** token-**based** **signs** **to** **include** **the** **first** **real** numerals. Previously, **units** **of** **grain** **had** **been** **represented** **by** **direct** **one**-**to**-**one** correspondence—**by** **repeating** **the** token **or** **symbol** **for** **a** **unit** **of** **grain** **the** **required** **number** **of** **times**. **The** **accountants**, **however**, devised numeral **signs** distinct **from** commodity **signs**, **so** **that** **eighteen** **units** **of** **grain** **could** **be** indicated **by** preceding **a** **single** **grain** **symbol** **with** **a** **symbol** denoting “18.” **Their** **invention** **of** **abstract** numerals **and** **abstract** **counting** **was** **one** **of** **the** **most** revolutionary **advances** **in** **the** **history** **of** **mathematics**.

**What** **was** **the** **social** **status** **of** **the** anonymous **accountants** **who** **produced** **this** **breakthrough**? **The** immense volume **of** **clay** **tablets** unearthed **in** **the** **ruins** **of** **the** Sumerian **temples** **where** **the** **accounts** **were** **kept** **suggests** **a** **social** differentiation **within** **the** scribal **class**, **with** **a** virtual **army** **of** lower-**ranking** tabulators **performing** **the** monotonous **job** **of** tallying commodities. **We** **can** **only** speculate **as** **to** **how** **high** **or** **low** **the** **inventors** **of** **true** numerals **were** **in** **the** scribal hierarchy, **but** **it** **stands** **to** **reason** **that** **this** laborsaving innovation **would** **have** **been** **the** brainchild **of** **the** lower-**ranking** **types** **whose** drudgery **it** **eased**.

count: 211

# Official 30-Passage 02 The Pace of Evolutionary Change

**A** **heated** **debate** **has** enlivened **recent** **studies** **of** **evolution**. Darwin’s original thesis, **and** **the** viewpoint **supported** **by** evolutionary gradualists, **is** **that** species **change** continuously **but** slowly **and** **in** **small** increments. **Such** **changes** **are** **all** **but** invisible **over** **the** **short** **time** scale **of** **modern** observations, **and**, **it** **is** **argued**, **they** **are** **usually** obscured **by** innumerable gaps **in** **the** imperfect fossil **record**. Gradualism, **with** **its** **stress** **on** **the** **slow** **pace** **of** **change**, **is** **a** **comforting** **position**, **repeated** **over** **and** **over** **again** **in** **generations** **of** **textbooks**. **By** **the** **early** **twentieth** **century**, **the** **question** **about** **the** **rate** **of** **evolution** **had** **been** **answered** **in** favor **of** gradualism **to** **most** biologists’ **satisfaction**.

**Sometimes** **a** **closed** **question** must **be** reopened **as** **new** **evidence** **or** **new** **arguments** **based** **on** **old** **evidence** **come** **to** **light**. **In** 1972 paleontologists Stephen Jay Gould **and** Niles Eldredge **challenged** **conventional** **wisdom** **with** an **opposing** viewpoint, **the** **punctuated** equilibrium hypothesis, **which** posits **that** species **give** **rise** **to** **new** species **in** relatively **sudden** **bursts**, **without** **a** lengthy transition **period**. **These** episodes **of** **rapid** **evolution** **are** **separated** **by** relatively **long** static spans **during** **which** **a** species may **hardly** **change** **at** **all**.

**The** **punctuated** equilibrium hypothesis **attempts** **to** **explain** **a** **curious** feature **of** **the** fossil **record**—**one** **that** **has** **been** **familiar** **to** paleontologists **for** **more** **than** **a** **century** **but** **has** **usually** **been** **ignored**. **Many** species **appear** **to** **remain** unchanged **in** **the** fossil **record** **for** **millions** **of** **years**—**a** **situation** **that** **seems** **to** **be** **at** odds **with** Darwin’s **model** **of** continuous **change**. Intermediate fossil **forms**, **predicted** **by** gradualism, **are** typically **lacking**. **In** **most** localities **a** **given** species **of** clam **or** **coral** persists essentially unchanged **throughout** **a** **thick** formation **of** **rock**, **only** **to** **be** **replaced** suddenly **by** **a** **new** **and** **different** species.

**The** **evolution** **of** **North** **American** **horses**, **which** **was** **once** **presented** **as** **a** **classic** **textbook** **example** **of** gradual **evolution**, **is** **now** **providing** equally compelling **evidence** **for** **punctuated** equilibrium. **A** **convincing** 50-**million**-**year** sequence **of** **modern** **horse** **ancestors**—**each** slightly larger, **with** **more** **complex** **teeth**, **a** longer **face**, **and** **a** **more** prominent **central** toe—**seemed** **to** **provide** **strong** **support** **for** Darwin’s contention **that** species evolve **gradually**. **But** **close** examination **of** **those** fossil **deposits** **now** reveals **a** somewhat **different** **story**. **Horses** evolved **in** discrete **steps**, **each** **of** **which** persisted **almost** unchanged **for** **millions** **of** **years** **and** **was** **eventually** **replaced** **by** **a** distinctive newer **model**. **The** **four**-toed Eohippus preceded **the** **three**-toed Miohippus, **for** **example**, **but** **North** **American** fossil **evidence** **suggests** **a** jerky, uneven transition **between** **the** **two**. **If** **evolution** **had** **been** **a** continuous, gradual **process**, **one** **might** **expect** **that** **almost** **every** fossil specimen **would** **be** slightly **different** **from** **every** **other**.

**If** **it** **seems** **difficult** **to** conceive **how** **major** **changes** **could** **occur** rapidly, **consider** **this**: an alteration **of** **a** **single** gene **in** **flies** **is** **enough** **to** **turn** **a** **normal** **fly** **with** **a** **single** **pair** **of** **wings** **into** **one** **that** **has** **two** **pairs** **of** **wings**.

**The** **question** **about** **the** **rate** **of** **evolution** must **now** **be** **turned** **around**: **does** **evolution** **ever** proceed **gradually**, **or** **does** **it** **always** **occur** **in** **short** **bursts**? Detailed **field** **studies** **of** **thick** **rock** formations **containing** fossils **provide** **the** **best** **potential** **tests** **of** **the** **competing** **theories**.

Occasionally, **a** sequence **of** fossil-**rich** layers **of** **rock** **permits** **a** comprehensive **look** **at** **one** **type** **of** organism **over** **a** **long** **period** **of** **time**. **For** **example**, Peter Sheldon’s **studies** **of** trilobites, **a** **now** extinct marine **animal** **with** **a** segmented body, **offer** **a** detailed glimpse **into** **three** **million** **years** **of** **evolution** **in** **one** marine **environment**. **In** **that** **study**, **each** **of** **eight** **different** trilobite species **was** **observed** **to** undergo **a** gradual **change** **in** **the** **number** **of** segments—typically an **increase** **of** **one** **or** **two** segments **over** **the** **whole** **time** **interval**. **No** significant discontinuities **were** **observed**, **leading** Sheldon **to** **conclude** **that** environmental **conditions** **were** **quite** **stable** **during** **the** **period** **he** **examined**.

**Similar** exhaustive **studies** **are** **required** **for** **many** **different** **kinds** **of** organisms **from** **many** **different** **periods**. **Most** researchers **expect** **to** **find** **that** **both** modes **of** transition **from** **one** species **to** **another** **are** **at** **work** **in** **evolution**. **Slow**, continuous **change** may **be** **the** norm **during** **periods** **of** environmental stability, **while** **rapid** **evolution** **of** **new** species **occurs** **during** **periods** **of** environmental **stress**. **But** **a** **lot** **more** **studies** **like** Sheldon’s **are** **needed** **before** **we** **can** **say** **for** **sure**.

count: 211

# Official 42-Passage 03 Explaining Dinosaur Extinction

**Dinosaurs** rapidly **became** extinct **about** 65 **million** **years** **ago** **as** **part** **of** **a** **mass** extinction **known** **as** **the** K–T **event**, **because** **it** **is** **associated** **with** **a** geological **signature** **known** **as** **the** K–T **boundary**, **usually** **a** **thin** **band** **of** sedimentation **found** **in** **various** **parts** **of** **the** **world** (K **is** **the** **traditional** abbreviation **for** **the** Cretaceous, derived **from** **the** **German** **name** Kreidezeit). **Many** **explanations** **have** **been** proposed **for** **why** **dinosaurs** **became** extinct. **For** **example**, **some** **have** **blamed** **dinosaur** extinction **on** **the** **development** **of** **flowering** **plants**, **which** **were** supposedly **more** **difficult** **to** **digest** **and** **could** **have** **caused** constipation **or** indigestion—**except** **that** **flowering** **plants** **first** evolved **in** **the** **Early** Cretaceous, **about** 60 **million** **years** **before** **the** **dinosaurs** **died** **out**. **In** **fact**, **several** **scientists** **have** **suggested** **that** **the** duckbill **dinosaurs** **and** horned **dinosaurs**, **with** **their** **complex** **battery** **of** grinding **teeth**, evolved **to** **exploit** **this** **new** resource **of** rapidly **growing** **flowering** **plants**. **Others** **have** **blamed** extinction **on** **competition** **from** **the** mammals, **which** allegedly **ate** **all** **the** **dinosaur** **eggs**—**except** **that** mammals **and** **dinosaurs** **appeared** **at** **the** **same** **time** **in** **the** **Late** Triassic, **about** 190 **million** **years** **ago**, **and** **there** **is** **no** **reason** **to** **believe** **that** mammals suddenly **acquired** **a** **taste** **for** **dinosaur** **eggs** after 120 **million** **years** **of** coexistence. **Some** **explanations** (**such** **as** **the** **one** **stating** **that** **dinosaurs** **all** **died** **of** **diseases**) **fail** **because** **there** **is** **no** **way** **to** scientifically **test** **them**, **and** **they** cannot **move** **beyond** **the** realm **of** speculation **and** guesswork.

**This** **focus** **on** **explaining** **dinosaur** extinction **misses** an **important** **point**: **the** extinction **at** **the** **end** **of** **the** Cretaceous **was** **a** global **event** **that** **killed** **off** organisms **up** **and** **down** **the** **food** **chain**. **It** **wiped** **out** **many** **kinds** **of** plankton **in** **the** **ocean** **and** **many** marine organisms **that** **lived** **on** **the** plankton **at** **the** **base** **of** **the** **food** **chain**. **These** **included** **a** **variety** **of** clams **and** snails, **and** **especially** **the** ammonites, **a** **group** **of** shelled squidlike **creatures** **that** dominated **the** Mesozoic **seas** **and** **had** **survived** **many** previous **mass** extinctions. **The** K–T **event** **marked** **the** **end** **of** **the** marine reptiles, **such** **as** **the** mosasaurs **and** **the** plesiosaurs, **which** **were** **the** largest **creatures** **that** **had** **ever** **lived** **in** **the** **seas** **and** **which** **ruled** **the** **seas** **long** **before** **whales** evolved. **On** **land**, **there** **was** **also** **a** crisis **among** **the** **land** **plants**, **in** **addition** **to** **the** disappearance **of** **dinosaurs**. **So** **any** **event** **that** **can** **explain** **the** destruction **of** **the** **base** **of** **the** **food** **chain** (plankton **in** **the** **ocean**, **plants** **on** **land**) **can** **better** **explain** **what** **happened** **to** organisms **at** **the** **top** **of** **the** **food** **chain**, **such** **as** **the** **dinosaurs**. **By** contrast, **any** **explanation** **that** **focuses** strictly **on** **the** **dinosaurs** completely **misses** **the** **point**. **The** Cretaceous extinctions **were** **a** global **phenomenon**, **and** **dinosaurs** **were** **just** **a** **part** **of** **a** bigger **picture**.

**According to** **one** **theory**, **the** **Age** **of** **Dinosaurs** **ended** suddenly 65 **million** **years** **ago** **when** **a** giant **rock** **from** **space** plummeted **to** **Earth**. Estimated **to** **be** **ten** **to** **fifteen** kilometers **in** diameter, **this** bolide (**either** **a** comet **or** an asteroid) **was** traveling **at** cosmic **speeds** **of** 20–70 kilometers **per** **second**, **or** 45,000–156,000 **miles** **per** **hour**. **Such** **a** **huge** **mass** traveling **at** **such** tremendous **speeds** **carries** an enormous **amount** **of** energy. **When** **the** bolide **struck**, **this** energy **was** released **and** generated **a** **huge** **shock** **wave** **that** leveled **everything** **for** **thousands** **of** kilometers **around** **the** impact **and** **caused** **most** **of** **the** landscape **to** **burst** **into** **flames**. **The** bolide **struck** an **area** **of** **the** Yucatán Peninsula **of** **Mexico** **known** **as** Chicxulub, excavating **a** crater 15–20 kilometers **deep** **and** **at** **least** 170 kilometers **in** diameter. **The** impact displaced **huge** volumes **of** seawater, **causing** **much** **flood** **damage** **in** **the** Caribbean. **Meanwhile**, **the** bolide **itself** excavated 100 **cubic** kilometers **of** **rock** **and** debris **from** **the** site, **which** **rose** **to** an **altitude** **of** 100 kilometers. **Most** **of** **it** **fell** **back** **immediately**, **but** **some** **of** **it** **remained** **as** **dust** **in** **the** **atmosphere** **for** **months**. **This** **material**, **along** **with** **the** **smoke** **from** **the** **fires**, shrouded **Earth**, **creating** **a** **form** **of** **nuclear** **winter**. **According to** computerized **climate** **models**, global **temperatures** **fell** **to** **near** **the** **freezing** **point**, photosynthesis halted, **and** **most** **plants** **on** **land** **and** **in** **the** **sea** **died**. **With** **the** **bottom** **of** **the** **food** **chain** **destroyed**, **dinosaurs** **could** **not** **survive**.

count: 210

# Official 09-Passage 02 Reflection in Teaching

**Teachers**, **it** **is** **thought**, **benefit** **from** **the** **practice** **of** reflection, **the** conscious **act** **of** **thinking** **deeply** **about** **and** carefully **examining** **the** interactions **and** **events** **within** **their** **own** **classrooms**. **Educators** T. Wildman **and** J. Niles (1987) **describe** **a** scheme **for** **developing** reflective **practice** **in** **experienced** **teachers**. **This** **was** justified **by** **the** **view** **that** reflective **practice** **could** **help** **teachers** **to** **feel** **more** intellectually involved **in** **their** **role** **and** **work** **in** **teaching** **and** enable **them** **to** cope **with** **the** paucity **of** **scientific** **fact** **and** **the** uncertainty **of** **knowledge** **in** **the** discipline **of** **teaching**.

Wildman **and** Niles **were** particularly **interested** **in** investigating **the** **conditions** **under** **which** reflection **might** flourish—**a** **subject** **on** **which** **there** **is** **little** **guidance** **in** **the** **literature**. **They** **designed** an experimental strategy **for** **a** **group** **of** **teachers** **in** Virginia **and** worked **with** 40 **practicing** **teachers** **over** **several** **years**. **They** **were** **concerned** **that** **many** **would** **be** “**drawn** **to** **these** **new**, **refreshing** conceptions **of** **teaching** **only** **to** **find** **that** **the** void **between** **the** abstractions **and** **the** **realities** **of** **teacher** reflection **is** **too** **great** **to** **bridge**. Reflection **on** **a** **complex** **task** **such** **as** **teaching** **is** **not** **easy**.” **The** **teachers** **were** **taken** **through** **a** program **of** **talking** **about** **teaching** **events**, **moving** **on** **to** **reflecting** **about** **specific** issues **in** **a** **supported**, **and** **later** an **independent**, **manner**.

Wildman **and** Niles **observed** **that** **systematic** reflection **on** **teaching** **required** **a** **sound** **ability** **to** **understand** **classroom** **events** **in** an objective **manner**. **They** **describe** **the** **initial** **understanding** **in** **the** **teachers** **with** **whom** **they** **were** **working** **as** **being** “utilitarian... **and** **not** **rich** **or** detailed **enough** **to** **drive** **systematic** reflection.” **Teachers** rarely **have** **the** **time** **or** opportunities **to** **view** **their** **own** **or** **the** **teaching** **of** **others** **in** an objective **manner**. Further observation revealed **the** **tendency** **of** **teachers** **to** **evaluate** **events** **rather** **than** **review** **the** contributory factors **in** **a** **considered** **manner** **by**, **in** **effect**, **standing** **outside** **the** **situation**.

**Helping** **this** **group** **of** **teachers** **to** revise **their** **thinking** **about** **classroom** **events** **became** **central**. **This** **process** **took** **time** **and** **patience** **and** effective **trainers**. **The** researchers estimate **that** **the** **initial** **training** **of** **the** **teachers** **to** **view** **events** objectively **took** **between** 20 **and** 30 **hours**, **with** **the** **same** **number** **of** **hours** **again** **being** **required** **to** **practice** **the** **skills** **of** reflection.

Wildman **and** Niles identify **three** **principles** **that** facilitate reflective **practice** **in** **a** **teaching** **situation**. **The** **first** **is** **support** **from** administrators **in** an **education** **system**, enabling **teachers** **to** **understand** **the** **requirements** **of** reflective **practice** **and** **how** **it** **relates** **to** **teaching** **students**. **The** **second** **is** **the** availability **of** sufficient **time** **and** **space**. **The** **teachers** **in** **the** program **described** **how** **they** **found** **it** **difficult** **to** **put** **aside** **the** **immediate** **demands** **of** **others** **in** **order** **to** **give** **themselves** **the** **time** **they** **needed** **to** **develop** **their** reflective **skills**. **The** **third** **is** **the** **development** **of** **a** collaborative **environment** **with** **support** **from** **other** **teachers**. **Support** **and** **encouragement** **were** **also** **required** **to** **help** **teachers** **in** **the** program cope **with** **aspects** **of** **their** professional **life** **with** **which** **they** **were** **not** **comfortable**. Wildman **and** Niles **make** **a** **summary** **comment**: “**Perhaps** **the** **most** **important** **thing** **we** **learned** **is** **the** **idea** **of** **the** **teacher**-**as**-reflective-practitioner **will** **not** **happen** **simply** **because** **it** **is** **a** **good** **or** **even** compelling **idea**.”

**The** **work** **of** Wildman **and** Niles **suggests** **the** **importance** **of** recognizing **some** **of** **the** **difficulties** **of** **instituting** reflective **practice**. **Others** **have** **noted** **this**, **making** **a** **similar** **point** **about** **the** **teaching** **profession**’s cultural inhibitions **about** reflective **practice**. Zeichner **and** Liston (1987) **point** **out** **the** inconsistency **between** **the** **role** **of** **the** **teacher** **as** **a** (reflective) professional **decision** maker **and** **the** **more** **usual** **role** **of** **the** **teacher** **as** **a** technician, **putting** **into** **practice** **the** **ideas** **of** **others**. **More** **basic** **than** **the** cultural issues **is** **the** **matter** **of** **motivation**. **Becoming** **a** reflective practitioner **requires** **extra** **work** (Jaworski, 1993) **and** **has** **only** vaguely defined **goals** **with**, **perhaps**, **little** initially perceivable **reward** **and** **the** threat **of** vulnerability. **Few** **have** directly **questioned** **what** **might** **lead** **a** **teacher** **to** **want** **to** **become** reflective. Apparently, **the** **most** **obvious** **reason** **for** **teachers** **to** **work** **toward** reflective **practice** **is** **that** **teacher** **educators** **think** **it** **is** **a** **good** **thing**. **There** **appear** **to** **be** **many** unexplored **matters** **about** **the** **motivation** **to** **reflect**—**for** **example**, **the** **value** **of** externally motivated reflection **as** **opposed** **to** **that** **of** **teachers** **who** **might** **reflect** **by** **habit**.

count: 210

# Official 23-Passage 02 Seventeenth-Century Dutch Agriculture

**Agriculture** **and** **fishing** **formed** **the** **primary** sector **of** **the** economy **in** **the** Netherlands **in** **the** seventeenth **century**. Dutch **agriculture** **was** modernized **and** commercialized: **new** **crops** **and** **agricultural** **techniques** **raised** **levels** **of** **production** **so** **that** **they** **were** **in** **line** **with** **market** **demands**, **and** **cheap** **grain** **was** **imported** annually **from** **the** Baltic region **in** **large** **quantities**. **According to** estimates, **about** 120,000 **tons** **of** **imported** **grain** **fed** **about** 600,000 **people**; **that** **is**, **about** **a** **third** **of** **the** Dutch **population**. **Importing** **the** **grain**, **which** **would** **have** **been** **expensive** **and** **time** **consuming** **for** **the** Dutch **to** **have** **produced** **themselves**, **kept** **the** **price** **of** **grain** **low** **and** **thus** stimulated individual **demand** **for** **other** foodstuffs **and** consumer **goods**.

**Apart** **from** **this**, **being** **able** **to** **give** **up** labor-intensive **grain** **production** **freed** **both** **the** **land** **and** **the** **workforce** **for** **more** productive **agricultural** **divisions**. **The** **peasants** specialized **in** livestock husbandry **and** dairy **farming** **as** **well** **as** **in** cultivating industrial **crops** **and** fodder **crops**; flax, madder, **and** rape **were** **grown**, **as** **were** **tobacco**, hops, **and** turnips. **These** **products** **were** **bought** mostly **by** **urban** **businesses**. **There** **was** **also** **a** **demand** **among** **urban** consumers **for** dairy **products** **such** **as** **butter** **and** **cheese**, **which**, **in** **the** **sixteenth** **century**, **had** **become** **more** **expensive** **than** **grain**. **The** **high** **prices** **encouraged** **the** **peasants** **to** **improve** **their** **animal** husbandry **techniques**; **for** **example**, **they** **began** **feeding** **their** **animals** indoors **in** **order** **to** **raise** **the** **milk** yield **of** **their** **cows**.

**In** **addition** **to** dairy **farming** **and** cultivating industrial **crops**, **a** **third** sector **of** **the** Dutch economy **reflected** **the** **way** **in** **which** **agriculture** **was** **being** modernized—horticulture. **In** **the** **sixteenth** **century**, **fruit** **and** **vegetables** **were** **to** **be** **found** **only** **in** **gardens** **belonging** **to** **wealthy** **people**. **This** **changed** **in** **the** **early** **part** **of** **the** seventeenth **century** **when** horticulture **became** **accepted** **as** an **agricultural** sector. **Whole** **villages** **began** **to** cultivate **fruit** **and** **vegetables**. **The** **produce** **was** **then** **transported** **by** **water** **to** **markets** **in** **the** **cities**, **where** **the** consumption **of** **fruit** **and** **vegetables** **was** **no** longer **restricted** **to** **the** **wealthy**.

**As** **the** **demand** **for** **agricultural** **produce** **from** **both** consumers **and** **industry** **increased**, **agricultural** **land** **became** **more** **valuable** **and** **people** **tried** **to** **work** **the** **available** **land** **more** intensively **and** **to** reclaim **more** **land** **from** wetlands **and** **lakes**. **In** **order** **to** **increase** **production** **on** **existing** **land**, **the** **peasants** **made** **more** **use** **of** **crop** rotation **and**, **in** **particular**, **began** **to** **apply** **animal** **waste** **to** **the** **soil** regularly, **rather** **than** **leaving** **the** fertilization **process** **up** **to** **the** grazing livestock. **For** **the** **first** **time** industrial **waste**, **such** **as** **ash** **from** **the** **soap**-boilers, **was** **collected** **in** **the** **cities** **and** **sold** **in** **the** **country** **as** **artificial** fertilizer. **The** **increased** yield **and** **price** **of** **land** justified reclaiming **and** draining **even** **more** **land**.

**The** Dutch **battle** **against** **the** **sea** **is** legendary. Noorderkwartier **in** Holland, **with** **its** numerous **lakes** **and** stretches **of** **water**, **was** particularly **suitable** **for** **land** reclamation **and** **one** **of** **the** biggest **projects** **undertaken** **there** **was** **the** draining **of** **the** Beemster **lake**, **which** **began** **in** 1608. **The** richest **merchants** **in** Amsterdam **contributed** **money** **to** reclaim **a** **good** 7,100 hectares **of** **land**. **Forty**-**three** windmills **powered** **the** drainage **pumps** **so** **that** **they** **were** **able** **to** lease **the** reclamation **to** **farmers** **as** **early** **as** 1612, **with** **the** investors **receiving** **annual** leasing payments **at** an **interest** **rate** **of** 17 **percent**. **Land** reclamation **continued**, **and** **between** 1590 **and** 1665 **almost** 100,000 hectares **were** reclaimed **from** **the** wetland **areas** **of** Holland, Zeeland, **and** Friesland. **However**, **land** reclamation **decreased** significantly after **the** **middle** **of** **the** seventeenth **century** **because** **the** **price** **of** **agricultural** **products** **began** **to** **fall**, **making** **land** reclamation **far** **less** profitable **in** **the** **second** **part** **of** **the** **century**.

Dutch **agriculture** **was** finally **affected** **by** **the** **general** **agricultural** crisis **in** **Europe** **during** **the** **last** **two** **decades** **of** **the** seventeenth **century**. **However**, **what** **is** **astonishing** **about** **this** **is** **not** **that** Dutch **agriculture** **was** **affected** **by** critical **phenomena** **such** **as** **a** **decrease** **in** **sales** **and** **production**, **but** **the** **fact** **that** **the** crisis **appeared** **only** relatively **late** **in** Dutch **agriculture**. **In** **Europe** **as** **a** **whole**, **the** exceptional reduction **in** **the** **population** **and** **the** **related** **fall** **in** **demand** **for** **grain** **since** **the** **beginning** **of** **the** seventeenth **century** **had** **caused** **the** **price** **of** **agricultural** **products** **to** **fall**. Dutch **peasants** **were** **able** **to** **remain** unaffected **by** **this** crisis **for** **a** **long** **time** **because** **they** **had** specialized **in** dairy **farming**, industrial **crops**, **and** horticulture. **However**, **toward** **the** **end** **of** **the** seventeenth **century**, **they** **too** **were** overtaken **by** **the** **general** **agricultural** crisis.

count: 210

# Official 35-Passage 02 The Development of Social Complexity

**For** **most** **of** **human** **history**, **we** **have** foraged (**hunted**, **fished**, **and** **collected** **wild** **plants**) **for** **food**. **Small** nomadic **groups** **could** **easily** **supply** **the** necessities **for** **their** **families**. **No** **one** **needed** **more**, **and** **providing** **for** **more** **than** **one**’s **needs** **made** **little** **sense**. **The** **organization** **of** **such** **societies** **could** **be** **rather** **simple**, revolving **around** **age** **and** gender **categories**. **Such** **societies** **likely** **were** largely egalitarian; **beyond** **distinctions** **based** **on** **age** **and** gender, virtually **all** **people** **had** equivalent **rights**, **status**, **and** **access** **to** resources.

Archaeologist Donald Henry **suggests** **that** **the** combination **of** **a** **rich** habitat **and** sedentism (**permanent**, **year**-**round** **settlement**) **led** **to** **a** dramatic **increase** **in** **human** **population**. **In** **his** **view**, nomadic, **simple** foragers **have** relatively **low** **levels** **of** fertility. **Their** **high**-protein, **low**-carbohydrate **diets** **result** **in** **low** body-**fat** **levels**, **which** **are** commonly **associated** **with** **low** fertility **in** **women**. **High** **levels** **of** **physical** **activity** **and** **long** **periods** **of** **nursing**, **which** **are** **common** **among** **modern** **simple** foragers, **probably** **also** **contributed** **to** **low** **levels** **of** **female** fertility **if** **they** **were** likewise **common** **among** **ancient** foragers.

**In** Henry’s **view**, **the** adoption **of** **a** **more** **settled** **existence** **in** **areas** **with** **abundant** **food** resources **would** **have** **contributed** **to** higher fertility **levels** **among** **the** sedentary foragers. **A** **diet** higher **in** **wild** cereals **produces** proportionally **more** body **fat**, **leading** **to** higher fertility **among** **women**. Cereals, **which** **are** **easy** **to** **digest**, **would** **have** supplemented **and** **then** **replaced** **mother**’s **milk** **as** **the** **primary** **food** **for** older infants. **Since** **women** **are** **less** fertile **when** **they** **are** **breast**-**feeding**, **substituting** cereals **for** **mother**’s **milk** **would** **have** **resulted** **in** closer **spacing** **of** **births** **and** **the** **potential** **for** **a** greater **number** **of** **live** **births** **for** **each** **woman**. **A** **more** sedentary **existence** may **also** **have** lowered infant mortality **and** **perhaps** **increased** longevity **among** **the** **aged**. **These** **more** vulnerable **members** **of** **society** **could** safely **stay** **in** **a** **fixed** **village** **rather** **than** **be** **forced** regularly **to** **move** **great** **distances** **as** **part** **of** **a** nomadic **existence**, **with** **its** greater **risk** **of** **accidents** **and** trauma.

**All** **of** **these** factors may **have** **resulted** **in** **a** **trend** **of** **increasing** **size** **among** **some** **local** **human** **populations** **in** **the** Holocene (**since** 9600 B.C.E.). **Given** sufficient **time**, **even** **in** **very** **rich** habitats, **human** **population** **size** **can** **reach** **carrying** capacity, **the** **maximum** **population** an **area** **can** sustain **within** **the** context **of** **a** **given** subsistence **system**. **And** **human** **population** **growth** **is** **like** **a** runaway **train**: **once** **it** **picks** **up** **speed**, **it** **is** **difficult** **to** **control**. **So** **even** after **reaching** an **area**’s **carrying** capacity, Holocene **human** **populations** **probably** **continued** **to** **grow** **in** **food**-**rich** regions, overshooting **the** **ability** **of** **the** territory **to** **feed** **the** **population**, **again** **within** **the** context **of** **the** **same** subsistence strategy. **In** **some** **areas**, **small** **changes** **in** **climate** **or** minor **changes** **in** **plant** **characteristics** may **have** further destabilized **local** economies.

**One** **possible** response **to** surpassing **the** **carrying** capacity **of** **a** region **is** **for** **a** **group** **to** **exploit** adjoining **land**. **However**, **good** **land** may **itself** **be** **limited**—**for** **example**, **to** **within** **the** confines **of** **a** **river** **valley**.

**Where** neighbors **are** **in** **the** **same** **position**, **having** **filled** **up** **the** **whole** **of** **the** desirable habitat **available** **in** **their** **home** territories, expansion **is** **also** problematic. Impinging **on** **the** neighbors’ territory **can** **lead** **to** **conflict**, **especially** **when** **they** **too** **are** **up** **against** **the** capacity **of** **the** **land** **to** **provide** **enough** **food**.

**Another** option **is** **to** **stay** **in** **the** **same** **area** **but** **to** shift **and** intensify **the** **food** quest **there**. **The** impulse **to** **produce** **more** **food** **to** **feed** **a** **growing** **population** **was** **satisfied** **in** **some** **areas** **by** **the** **development** **of** **more**-**complex** subsistence strategies involving intensive labor **and** **requiring** **more** cooperation **and** greater coordination **among** **the** **increasing** **numbers** **of** **people**. **This** **development** **resulted** **in** **a** **change** **in** **the** **social** **and** economic equations **that** defined **those** **societies**. Hierarchies **that** **did** **not** **exist** **in** earlier foraging **groups** **but** **that** **were** **helpful** **in** structuring cooperative labor **and** **in** organizing **more**-**complex** **technologies** **probably** **became** established, **even** **before** domestication **and** **agriculture**, **as** pre-Neolithic **societies** (**before** **the** tenth millennium B.C.E.) **reacted** **to** **the** **population** **increase**.

count: 210

# Official 19-Passage 03 Discovering the Ice Ages

**In** **the** **middle** **of** **the** nineteenth **century**, Louis Agassiz, **one** **of** **the** **first** **scientists** **to** **study** glaciers, immigrated **to** **the** **United** **States** **from** **Switzerland** **and** **became** **a** **professor** **at** Harvard **University**, **where** **he** **continued** **his** **studies** **in** geology **and** **other** **sciences**. **For** **his** **research**, Agassiz **visited** **many** **places** **in** **the** **northern** **parts** **of** **Europe** **and** **North** **America**, **from** **the** **mountains** **of** Scandinavia **and** **New** **England** **to** **the** **rolling** **hills** **of** **the** **American** Midwest. **In** **all** **these** **diverse** regions, Agassiz **saw** **signs** **of** glacial erosion **and** sedimentation. **In** **flat** **plains** **country**, **he** **saw** moraines (accumulations **of** **earth** **and** **loose** **rock** **that** **form** **at** **the** **edges** **of** glaciers) **that** **reminded** **him** **of** **the** **terminal** moraines **found** **at** **the** **end** **of** **valley** glaciers **in** **the** Alps. **The** heterogeneous **material** **of** **the** drift (**sand**, **clay**, **and** **rocks** **deposited** **there**) **convinced** **him** **of** **its** glacial **origin**.

**The** **areas** **covered** **by** **this** **material** **were** **so** **vast** **that** **the** **ice** **that** **deposited** **it** must **have** **been** **a** continental glacier larger **than** Greenland **or** **Antarctica**. **Eventually**, Agassiz **and** **others** **convinced** geologists **and** **the** **general** **public** **that** **a** **great** continental glaciation **had** extended **the** polar **ice** **caps** **far** **into** regions **that** **now** **enjoy** temperate **climates**. **For** **the** **first** **time**, **people** **began** **to** **talk** **about** **ice** **ages**. **It** **was** **also** **apparent** **that** **the** glaciation **occurred** **in** **the** relatively **recent** **past** **because** **the** drift **was** **soft**, **like** freshly **deposited** sediment. **We** **now** **know** **the** **age** **of** **the** glaciation accurately **from** radiometric **dating** **of** **the** **carbon**-14 **in** logs **buried** **in** **the** drift. **The** drift **of** **the** **last** glaciation **was** **deposited** **during** **one** **of** **the** **most** **recent** epochs **of** geologic **time**, **the** Pleistocene, **which** **lasted** **from** 2.6 **million** **to** 11,700 **years** **ago**. **Along** **the** **east** **coast** **of** **the** **United** **States**, **the** southernmost **advance** **of** **this** **ice** **is** **recorded** **by** **the** enormous **sand** **and** drift **deposits** **of** **the** **terminal** moraines **that** **form** **Long** **Island** **and** Cape Cod.

**It** **soon** **became** **clear** **that** **there** **were** multiple glacial **ages** **during** **the** Pleistocene, **with** warmer interglacial **intervals** **between** **them**. **As** geologists **mapped** glacial **deposits** **in** **the** **late** nineteenth **century**, **they** **became** **aware** **that** **there** **were** **several** layers **of** drift, **the** lower **ones** **corresponding** **to** earlier **ice** **ages**. **Between** **the** older layers **of** glacial **material** **were** **well**-**developed** **soils** **containing** fossils **of** **warm**-**climate** **plants**. **These** **soils** **were** **evidence** **that** **the** glaciers retreated **as** **the** **climate** **warmed**. **By** **the** **early** **part** **of** **the** **twentieth** **century**, **scientists** **believed** **that** **four** distinct glaciations **had** **affected** **North** **America** **and** **Europe** **during** **the** Pleistocene epoch.

**This** **idea** **was** modified **in** **the** **late** **twentieth** **century**, **when** geologists **and** oceanographers **examining** oceanic sediment **found** fossil **evidence** **of** **warming** **and** **cooling** **of** **the** **oceans**. **Ocean** sediments **presented** **a** **much** **more** **complete** geologic **record** **of** **the** Pleistocene **than** continental glacial **deposits** **did**. **The** fossils **buried** **in** Pleistocene **and** earlier **ocean** sediments **were** **of** foraminifera—**small**, **single**-**celled** marine organisms **that** secrete shells **of** calcium carbonate, **or** calcite. **These** shells **differ** **in** **their** proportion **of** **ordinary** **oxygen** (**oxygen**-16) **and** **the** **heavy** **oxygen** isotope (**oxygen**-18). **The** ratio **of** **oxygen**-16 **to** **oxygen**-18 **found** **in** **the** calcite **of** **a** foraminifer’s shell **depends** **on** **the** **temperature** **of** **the** **water** **in** **which** **the** organism **lived**. **Different** ratios **in** **the** shells **preserved** **in** **various** layers **of** sediment reveal **the** **temperature** **changes** **in** **the** **oceans** **during** **the** Pleistocene epoch.

Isotopic **analysis** **of** shells **allowed** geologists **to** **measure** **another** glacial **effect**. **They** **could** trace **the** **growth** **and** shrinkage **of** continental glaciers, **even** **in** **parts** **of** **the** **ocean** **where** **there** may **have** **been** **no** **great** **change** **in** **temperature**—**around** **the** equator, **for** **example**. **The** **oxygen** isotope ratio **of** **the** **ocean** **changes** **as** **a** **great** **deal** **of** **water** **is** **withdrawn** **from** **it** **by** evaporation **and** **is** precipitated **as** **snow** **to** **form** glacial **ice**. **During** glaciations, **the** lighter **oxygen**-16 **has** **a** greater **tendency** **to** evaporate **from** **the** **ocean** **surface** **than** **the** heavier **oxygen**-18 **does**. **Thus**, **more** **of** **the** **heavy** isotope **is** **left** **behind** **in** **the** **ocean** **and** **absorbed** **by** marine organisms. **From** **this** **analysis** **of** marine sediments, geologists **have** **learned** **that** **there** **were** **many** shorter, **more** **regular** **cycles** **of** glaciation **and** deglaciation **than** geologists **had** recognized **from** **the** glacial drift **of** **the** **continents** **alone**.

count: 209

# Official 48-Passage 03 Climate and Urban Development

**For** **more** **than** **a** **hundred** **years**, **it** **has** **been** **known** **that** **cities** **are** generally warmer **than** **surrounding** rural **areas**. **This** region **of** **city** **warmth**, **known** **as** **the** **urban** **heat** **island**, **can** **influence** **the** concentration **of** **air** **pollution**. **However**, **before** **we** **look** **at** **its** **influence**, **let**’s **see** **how** **the** **heat** **island** actually **forms**.

**The** **urban** **heat** **island** **is** **due** **to** industrial **and** **urban** **development**. **In** rural **areas**, **a** **large** **part** **of** **the** **incoming** **solar** energy **is** **used** **in** evaporating **water** **from** vegetation **and** **soil**. **In** **cities**, **where** **less** vegetation **and** **exposed** **soil** **exist**, **the** **majority** **of** **the** **Sun**’s energy **is** **absorbed** **by** **urban** structures **and** asphalt. Hence, **during** **warm** **daylight** **hours**, **less** evaporative **cooling** **in** **cities** **allows** **surface** **temperatures** **to** **rise** higher **than** **in** rural **areas**. **The** **cause** **of** **the** **urban** **heat** **island** **is** **quite** involved. **Depending** **on** **the** location, **time** **of** **year**, **and** **time** **of** **day**, **any** **or** **all** **of** **the** **following** **differences** **between** **cities** **and** **their** **surroundings** **can** **be** **important**: albedo (reflectivity **of** **the** **surface**), **surface** roughness, emissions **of** **heat**, emissions **of** moisture, **and** emissions **of** particles **that** **affect** **net** **radiation** **and** **the** **growth** **of** **cloud** droplets.

**At** **night**, **the** **solar** energy (**stored** **as** **vast** **quantities** **of** **heat** **in** **city** **buildings** **and** **roads**) **is** slowly released **into** **the** **city** **air**. Additional **city** **heat** **is** **given** **off** **at** **night** (**and** **during** **the** **day**) **by** **vehicles** **and** **factories**, **as** **well** **as** **by** industrial **and** domestic **heating** **and** **cooling** **units**. **The** release **of** **heat** energy **is** retarded **by** **the** **tall** **vertical** **city** **walls** **that** **do** **not** **allow** infrared **radiation** **to** **escape** **as** readily **as** **does** **the** relatively **level** **surface** **of** **the** **surrounding** **countryside**. **The** **slow** release **of** **heat** **tends** **to** **keep** nighttime **city** **temperatures** higher **than** **those** **of** **the** faster-**cooling** rural **areas**. Overall, **the** **heat** **island** **is** strongest (1) **at** **night** **when** **compensating** **sunlight** **is** **absent**; (2) **during** **the** **winter**, **when** **nights** **are** longer **and** **there** **is** **more** **heat** generated **in** **the** **city**; **and** (3) **when** **the** region **is** dominated **by** **a** **high**-**pressure** **air** **pressure** (atmospheric **pressure**) **is** **the** **pressure** exerted **by** **the** **mass** **of** **air** **above** **a** **given** **place** **area** **with** **light** **winds**, **clear** **skies**, **and** **less** humid **air**. **Over** **time**, **increasing** **urban** **heat** **islands** **affect** climatological **temperature** **records**, **producing** **artificial** **warming** **in** climatic **records** **taken** **in** **cities**. **This** **warming**, **therefore**, must **be** **accounted** **for** **in** interpreting **climate** **change** **over** **the** **past** **century**.

**The** **constant** outpouring **of** pollutants **into** **the** **environment** may **influence** **the** **climate** **of** **the** **city**. **Certain** particles **reflect** **solar** **radiation**, thereby **reducing** **the** **sunlight** **that** **reaches** **the** **surface**. **Some** particles **serve** **as** nuclei **upon** **which** **water** **and** **ice** **form**. **Water** vapor condenses **onto** **these** particles **when** **the** **relative** humidity **is** **as** **low** **as** 70 **percent**, **forming** haze **that** greatly **reduces** visibility. Moreover, **the** **added** nuclei **increase** **the** frequency **of** **city** **fog**.

**Studies** **suggest** **that** precipitation may **be** greater **in** **cities** **than** **in** **the** **surrounding** **countryside**; **this** **phenomenon** may **be** **due** **in** **part** **to** **the** **increased** roughness **of** **city** terrain, **brought** **on** **by** **large** structures **that** **cause** **surface** **air** **to** **slow** **and** **gradually** converge. **This** **piling** **up** **of** **air** **over** **the** **city** **then** slowly **rises**, **much** **like** **toothpaste** **does** **when** **its** **tube** **is** **squeezed**. **At** **the** **same** **time**, **city** **heat** **warms** **the** **surface** **air**, **making** **it** **more** unstable, **which** enhances **rising** **air** motions, **which**, **in** **turn**, **aids** **in** **forming** **clouds** **and** **thunderstorms**. **This** **process** **helps** **explain** **why** **both** **tend** **to** **be** **more** **frequent** **over** **cities**.

**On** **clear** **still** **nights** **when** **the** **heat** **island** **is** **pronounced**, **a** **small** thermal **low**-**pressure** **area** **forms** **over** **the** **city**. **Sometimes** **a** **light** breeze—**called** **a** **country** breeze—**blows** **from** **the** **countryside** **into** **the** **city**. **If** **there** **are** **major** industrial **areas** **along** **the** outskirts, pollutants **are** **carried** **into** **the** **heart** **of** **town**, **where** **they** **tend** **to** **concentrate**. **Such** an **event** **is** **especially** **probable** **if** **vertical** **mixing** **and** dispersion **of** pollutants **are** inhibited. Pollutants **from** **urban** **areas** may **even** **affect** **the** **weather** downwind **from** **them**.

count: 209

# Official 11-Passage 03 Begging by Nestlings

**Many** **signals** **that** **animals** **make** **seem** **to** impose **on** **the** signalers **costs** **that** **are** overly **damaging**. **A** **classic** **example** **is** **noisy** **begging** **by** nestling songbirds **when** **a** **parent** **returns** **to** **the** **nest** **with** **food**. **These** **loud** cheeps **and** peeps **might** **give** **the** location **of** **the** **nest** **away** **to** **a** **listening** **hawk** **or** raccoon, **resulting** **in** **the** **death** **of** **the** defenseless nestlings. **In** **fact**, **when** **tapes** **of** **begging** **tree** **swallows** **were** **played** **at** an **artificial** **swallow** **nest** **containing** an **egg**, **the** **egg** **in** **that** “**noisy**” **nest** **was** **taken** **or** **destroyed** **by** predators **before** **the** **egg** **in** **a** **nearby** **quiet** **nest** **in** 29 **of** 37 **trials**.

Further **evidence** **for** **the** **costs** **of** **begging** **comes** **from** **a** **study** **of** **differences** **in** **the** **begging** **calls** **of** warbler species **that** **nest** **on** **the** **ground** versus **those** **that** **nest** **in** **the** **relative** **safety** **of** **trees**. **The** **young** **of** **ground**-**nesting** warblers **produce** **begging** cheeps **of** higher frequencies **than** **do** **their** **tree**-**nesting** **relatives**. **These** higher-frequency **sounds** **do** **not** **travel** **as** **far**, **and** **so** may **better** conceal **the** individuals **producing** **them**, **who** **are** **especially** vulnerable **to** predators **in** **their** **ground** **nests**. David Haskell **created** **artificial** **nests** **with** **clay** **eggs** **and** **placed** **them** **on** **the** **ground** **beside** **a** **tape recorder** **that** **played** **the** **begging** **calls** **of** **either** **tree**-**nesting** **or** **of** **ground**-**nesting** warblers. **The** **eggs** “**advertised**” **by** **the** **tree**-nesters’ **begging** **calls** **were** **found** **bitten** significantly **more** **often** **than** **the** **eggs** **associated** **with** **the** **ground**-nesters’ **calls**.

**The** hypothesis **that** **begging** **calls** **have** evolved properties **that** **reduce** **their** **potential** **for** **attracting** predators yields **a** prediction: baby **birds** **of** species **that** **experience** **high** **rates** **of** **nest** predation **should** **produce** softer **begging** **signals** **of** higher frequency **than** nestlings **of** **other** species **less** **often** victimized **by** **nest** predators. **This** prediction **was** **supported** **by** **data** **collected** **in** **one** survey **of** 24 species **from** an Arizona **forest**, **more** **evidence** **that** predator **pressure** favors **the** **evolution** **of** **begging** **calls** **that** **are** **hard** **to** detect **and** pinpoint.

**Given** **that** predators **can** **make** **it** costly **to** **beg** **for** **food**, **what** **benefit** **do** **begging** nestlings derive **from** **their** **communications**? **One** **possibility** **is** **that** **a** **noisy** baby **bird** **provides** accurate **signals** **of** **its** **real** **hunger** **and** **good** **health**, **making** **it** **worthwhile** **for** **the** **listening** **parent** **to** **give** **it** **food** **in** **a** **nest** **where** **several** **other** offspring **are** **usually** **available** **to** **be** **fed**. **If** **this** hypothesis **is** **true**, **then** **it** **follows** **that** nestlings **should** **adjust** **the** intensity **of** **their** **signals** **in** **relation** **to** **the** **signals** **produced** **by** **their** nestmates, **who** **are** **competing** **for** parental **attention**. **When** experimentally deprived baby robins **are** **placed** **in** **a** **nest** **with** normally **fed** siblings, **the** **hungry** nestlings **beg** **more** **loudly** **than** **usual**—**but** **so** **do** **their** **better**-**fed** siblings, **though** **not** **as** **loudly** **as** **the** hungrier **birds**.

**If** **parent** **birds** **use** **begging** intensity **to** **direct** **food** **to** **healthy** offspring capable **of** vigorous **begging**, **then** **parents** **should** **make** **food** delivery **decisions** **on** **the** **basis** **of** **their** offspring’s **calls**. **Indeed**, **if** **you** **take** baby **tree** **swallows** **out** **of** **a** **nest** **for** an **hour**, **feeding** **half** **the** **set** **and** **starving** **the** **other** **half**, **when** **the** **birds** **are** **replaced** **in** **the** **nest**, **the** **starved** youngsters **beg** **more** **loudly** **than** **the** **fed** **birds**, **and** **the** **parent** **birds** **feed** **the** **active** beggars **more** **than** **those** **who** **beg** **less** vigorously.

**As** **these** **experiments** **show**, **begging** apparently **provides** **a** **signal** **of** **need** **that** **parents** **use** **to** **make** judgments **about** **which** offspring **can** **benefit** **most** **from** **a** **feeding**. **But** **the** **question** **arises**, **why** don’t nestlings **beg** **loudly** **when** **they** aren’t **all** **that** **hungry**? **By** **doing** **so**, **they** **could** **possibly** **secure** **more** **food**, **which** **should** **result** **in** **more** **rapid** **growth** **or** larger **size**, **either** **of** **which** **is** advantageous. **The** **answer** **lies** apparently **not** **in** **the** **increased** energy **costs** **of** exaggerated **begging**—**such** energy **costs** **are** **small** **relative** **to** **the** **potential** **gain** **in** calories—**but** **rather** **in** **the** **damage** **that** **any** **successful** cheater **would** **do** **to** **its** siblings, **which** **share** genes **with** **one** **another**. An individual’s **success** **in** propagating **his** **or** **her** genes **can** **be** **affected** **by** **more** **than** **just** **his** **or** **her** **own** **personal** reproductive **success**. **Because** **close** **relatives** **have** **many** **of** **the** **same** genes, **animals** **that** **harm** **their** **close** **relatives** may **in** **effect** **be** **destroying** **some** **of** **their** **own** genes. **Therefore**, **a** **begging** nestling **that** **secures** **food** **at** **the** **expense** **of** **its** siblings **might** actually **leave** **behind** fewer **copies** **of** **its** genes overall **than** **it** **might** **otherwise**.

count: 209

# Official 10-Passage 03 Seventeenth-Century European Economic Growth

**In** **the** **late** **sixteenth** **century** **and** **into** **the** seventeenth, **Europe** **continued** **the** **growth** **that** **had** **lifted** **it** **out** **of** **the** relatively **less** prosperous medieval **period** (**from** **the** mid 400s **to** **the** **late** 1400s). **Among** **the** **key** factors **behind** **this** **growth** **were** **increased** **agricultural** productivity **and** an expansion **of** **trade**.

**Populations** cannot **grow** **unless** **the** rural economy **can** **produce** **enough** additional **food** **to** **feed** **more** **people**. **During** **the** **sixteenth** **century**, **farmers** **brought** **more** **land** **into** cultivation **at** **the** **expense** **of** **forests** **and** fens (**low**-**lying** wetlands). Dutch **land** reclamation **in** **the** Netherlands **in** **the** **sixteenth** **and** seventeenth **centuries** **provides** **the** **most** spectacular **example** **of** **the** expansion **of** farmland: **the** Dutch reclaimed **more** **than** 36,000 **acres** **from**1590 **to**1615 **alone**.

**Much** **of** **the** **potential** **for** **European** economic **development** **lay** **in** **what** **at** **first** **glance** **would** **seem** **to** **have** **been** **only** **sleepy** **villages**. **Such** **villages**, **however**, generally **lay** **in** regions **of** relatively **advanced** **agricultural** **production**, **permitting** **not** **only** **the** **survival** **of** **peasants** **but** **also** **the** accumulation **of** an **agricultural** **surplus** **for** investment. **They** **had** **access** **to** **urban** **merchants**, **markets**, **and** **trade** routes.

**Increased** **agricultural** **production** **in** **turn** facilitated rural **industry**, an intrinsic **part** **of** **the** expansion **of** **industry**. Woolens **and** textile manufacturers, **in** **particular**, utilized rural **cottage** (**in**-**home**) **production**, **which** **took** **advantage** **of** **cheap** **and** plentiful rural labor. **In** **the** **German** **states**, **the** ravages **of** **the** **Thirty** **Years**’ **War** (1618–1648) further **moved** textile **production** **into** **the** **countryside**. **Members** **of** **poor** **peasant** **families** **spun** **or** wove **cloth** **and** linens **at** **home** **for** scant remuneration **in** an **attempt** **to** supplement meager **family** **income**.

**More** extended **trading** **networks** **also** **helped** **develop** **Europe**’s economy **in** **this** **period**. **English** **and** Dutch **ships** **carrying** rye **from** **the** Baltic **states** **reached** **Spain** **and** Portugal. **Population** **growth** generated an expansion **of** **small**-scale manufacturing, particularly **of** handicrafts, textiles, **and** **metal** **production** **in** **England**, Flanders, **parts** **of** **northern** **Italy**, **the** southwestern **German** **states**, **and** **parts** **of** **Spain**. **Only** **iron** smelting **and** **mining** **required** marshaling **a** significant **amount** **of** **capital** (**wealth** invested **to** **create** **more** **wealth**).

**The** **development** **of** **banking** **and** **other** financial **services** **contributed** **to** **the** expansion **of** **trade**. **By** **the** **middle** **of** **the** **sixteenth** **century**, financiers **and** traders commonly **accepted** **bills** **of** **exchange** **in** **place** **of** **gold** **or** **silver** **for** **other** **goods**. **Bills** **of** **exchange**, **which** **had** **their** **origins** **in** medieval **Italy**, **were** promissory **notes** (**written** **promises** **to** **pay** **a** specified **amount** **of** **money** **by** **a** **certain** **date**) **that** **could** **be** **sold** **to** **third** **parties**. **In** **this** **way**, **they** **provided** **credit**. **At** mid-**century**, an Antwerp financier **only** slightly exaggerated **when** **he** claimed, “**One** **can** **no** **more** **trade** **without** **bills** **of** **exchange** **than** **sail** **without** **water**.” **Merchants** **no** longer **had** **to** **carry** **gold** **and** **silver** **over** **long**, **dangerous** **journeys**. An Amsterdam **merchant** **purchasing** **soap** **from** **a** **merchant** **in** Marseille **could** **go** **to** an exchanger **and** **pay** **the** exchanger **the** equivalent sum **in** guilders, **the** Dutch **currency**. **The** exchanger **would** **then** **send** **a** **bill** **of** **exchange** **to** **a** **colleague** **in** Marseille, authorizing **the** **colleague** **to** **pay** **the** Marseille **merchant** **in** **the** **merchant**’s **own** **currency** after **the** **actual** **exchange** **of** **goods** **had** **taken** **place**.

**Bills** **of** **exchange** **contributed** **to** **the** **development** **of** **banks**, **as** exchangers **began** **to** **provide** loans. **Not** **until** **the** eighteenth **century**, **however**, **did** **such** **banks** **as** **the** **Bank** **of** Amsterdam **and** **the** **Bank** **of** **England** **begin** **to** **provide** **capital** **for** **business** investment. **Their** principal **function** **was** **to** **provide** funds **for** **the** **state**.

**The** **rapid** expansion **in** **international** **trade** **also** **benefitted** **from** an infusion **of** **capital**, stemming largely **from** **gold** **and** **silver** **brought** **by** **Spanish** vessels **from** **the** Americas. **This** **capital** **financed** **the** **production** **of** **goods**, **storage**, **trade**, **and** **even** **credit** **across** **Europe** **and** overseas. Moreover, an **increased** **credit** **supply** **was** generated **by** investments **and** loans **by** bankers **and** **wealthy** **merchants** **to** **states** **and** **by** joint-stock partnerships– an **English** innovation （**the** **first** **major** **company** **began** **in** 1600）. **Unlike** **short**-**term** financial cooperation **between** investors **for** **a** **single** commercial **undertaking**, joint-stock **companies** **provided** **permanent** funding **of** **capital** **by** **drawing** **on** **the** investments **of** **merchants** **and** **other** investors **who** **purchased** **shares** **in** **the** **company**.

count: 209

# Official 45-Passage 01 The Beringia Landscape

**During** **the** peak **of** **the** **last** **ice** **age**, **northeast** **Asia** (Siberia) **and** Alaska **were** **connected** **by** **a** **broad** **land** **mass** **called** **the** Bering **Land** **Bridge**. **This** **land** **bridge** **existed** **because** **so** **much** **of** **Earth**’s **water** **was** **frozen** **in** **the** **great** **ice** **sheets** **that** **sea** **levels** **were** **over** 100 meters lower **than** **they** **are** **today**. **Between** 25,000 **and** 10,000 **years** **ago**, Siberia, **the** Bering **Land** **Bridge**, **and** Alaska **shared** **many** environmental **characteristics**. **These** **included** **a** **common** mammalian fauna **of** **large** mammals, **a** **common** flora composed **of** **broad** grasslands **as** **well** **as** **wind**-**swept** dunes **and** tundra, **and** **a** **common** **climate** **with** **cold**, **dry** **winters** **and** somewhat warmer **summers**. **The** recognition **that** **many** **aspects** **of** **the** **modern** flora **and** fauna **were** **present** **on** **both** **sides** **of** **the** Bering **Sea** **as** remnants **of** **the** **ice**-**age** landscape **led** **to** **this** region **being** **named** Beringia.

**It** **is** **through** Beringia **that** **small** **groups** **of** **large** mammal **hunters**, slowly **expanding** **their** **hunting** territories, **eventually** colonized **North** **and** **South** **America**. **On** **this** archaeologists generally **agree**, **but** **that** **is** **where** **the** **agreement** **stops**. **One** **broad** **area** **of** **disagreement** **in** **explaining** **the** **peopling** **of** **the** Americas **is** **the** domain **of** paleoecologists, **but** **it** **is** critical **to** **understanding** **human** **history**: **what** **was** Beringia **like**?

**The** Beringian landscape **was** **very** **different** **from** **what** **it** **is** **today**. **Broad**, windswept **valleys**; glaciated **mountains**; sparse vegetation; **and** **less** moisture **created** **a** **rather** **forbidding** **land** **mass**. **This** **land** **mass** **supported** herds **of** **now**-extinct species **of** mammoth, bison, **and** **horse** **and** somewhat **modern** **versions** **of** caribou, musk **ox**, elk, **and** saiga antelope. **These** grazers **supported** **in** **turn** **a** **number** **of** impressive carnivores, **including** **the** giant **short**-**faced** **bear**, **the** saber-**tooth** **cat**, **and** **a** **large** species **of** **lion**.

**The** presence **of** mammal species **that** **require** grassland vegetation **has** **led** **Arctic** biologist Dale Guthrie **to** **argue** **that** **while** **cold** **and** **dry**, **there** must **have** **been** **broad** **areas** **of** dense vegetation **to** **support** herds **of** mammoth, **horse**, **and** bison. Further, **nearly** **all** **of** **the** **ice**-**age** fauna **had** **teeth** **that** indicate an **adaptation** **to** **grasses** **and** sedges; **they** **could** **not** **have** **been** **supported** **by** **a** **modern** flora **of** mosses **and** lichens. Guthrie **has** **also** demonstrated **that** **the** landscape must **have** **been** **subject** **to** intense **and** continuous **winds**, **especially** **in** **winter**. **He** **makes** **this** **argument** **based** **on** **the** anatomy **of** **horse** **and** bison, **which** **do** **not** **have** **the** **ability** **to** **search** **for** **food** **through** **deep** **snow** **cover**. **They** **need** landscapes **with** **strong** **winds** **that** **remove** **the** **winter** **snows**, **exposing** **the** **dry** **grasses** **beneath**. Guthrie **applied** **the** **term** “mammoth steppe” **to** characterize **this** landscape.

**In** contrast, Paul Colinvaux **has** **offered** **a** counterargument **based** **on** **the** **analysis** **of** pollen **in** **lake** sediments **dating** **to** **the** **last** **ice** **age**. **He** **found** **that** **the** **amount** **of** pollen **recovered** **in** **these** sediments **is** **so** **low** **that** **the** Beringian landscape **during** **the** peak **of** **the** **last** glaciation **was** **more** **likely** **to** **have** **been** **what** **he** **termed** **a** “polar **desert**,” **with** **little** **or** **only** sparse vegetation. **In** **no** **way** **was** **it** **possible** **that** **this** region **could** **have** **supported** **large** herds **of** mammals **and** **thus**, **human** **hunters**. Guthrie **has** **argued** **against** **this** **view** **by** **pointing** **out** **that** radiocarbon **analysis** **of** mammoth, **horse**, **and** bison **bones** **from** Beringian **deposits** revealed **that** **the** **bones** **date** **to** **the** **period** **of** **most** intense glaciation.

**The** **argument** **seemed** **to** **be** **at** **a** standstill **until** **a** **number** **of** **recent** **studies** **resulted** **in** **a** spectacular **suite** **of** **new** **finds**. **The** **first** **was** **the** **discovery** **of** **a** 1,000-**square**-kilometer **preserved** patch **of** Beringian vegetation **dating** **to** **just** **over** 17,000 **years** **ago**—**the** peak **of** **the** **last** **ice** **age**. **The** **plants** **were** **preserved** **under** **a** **thick** **ash** **fall** **from** **a** volcanic eruption. Investigations **of** **the** **plants** **found** **grasses**, sedges, mosses, **and** **many** **other** **varieties** **in** **a** **nearly** continuous **cover**, **as** **was** **predicted** **by** Guthrie. **But** **this** vegetation **had** **a** **thin** **root** **mat** **with** **no** **soil** formation, demonstrating **that** **there** **was** **little** **long**-**term** stability **in** **plant** **cover**, **a** **finding** **supporting** **some** **of** **the** **arguments** **of** Colinvaux. **A** **mixture** **of** continuous **but** **thin** vegetation **supporting** herds **of** **large** mammals **is** **one** **that** **seems** plausible **and** realistic **with** **the** **available** **data**.

count: 209

# Official 50-Passage 03 Star Death

**Until** **the** **early**- **to** mid-**twentieth** **century**, **scientists** **believed** **that** **stars** generate energy **by** **shrinking**. **As** **stars** contracted, **it** **was** **thought**, **they** **would** **get** hotter **and** hotter, **giving** **off** **light** **in** **the** **process**. **This** **could** **not** **be** **the** **primary** **way** **that** **stars** **shine**, **however**. **If** **it** **were**, **they** **would** scarcely **last** **a** **million** **years**, **rather** **than** **the** **billions** **of** **years** **in** **age** **that** **we** **know** **they** **are**. **We** **now** **know** **that** **stars** **are** **fueled** **by** **nuclear** fusion. **Each** **time** fusion **takes** **place**, energy **is** released **as** **a** **by**-**product**. **This** energy, expelled **into** **space**, **is** **what** **we** **see** **as** starlight. **The** fusion **process** **begins** **when** **two** **hydrogen** nuclei smash **together** **to** **form** **a** particle **called** **the** deuteron (**a** combination **of** **a** positive proton **and** **a** neutral neutron). Deuterons readily **combine** **with** additional protons **to** **form** helium. Helium, **in** **turn**, **can** fuse **together** **to** **form** heavier elements, **such** **as** **carbon**. **In** **a** **typical** **star**, merger after merger **takes** **place** **until** significant **quantities** **of** **heavy** elements **are** **built** **up**.

**We** must **distinguish**, **at** **this** **point**, **between** **two** **different** stellar **types**: **Population** **I** **and** **Population** II, **the** **latter** **being** **much** older **than** **the** **former**. **These** **groups** **can** **also** **be** **distinguished** **by** **their** locations. **Our** galaxy, **the** Milky **Way**, **is** **shaped** **like** **a** **flat** **disk** **surrounding** **a** **central** bulge. Whereas **Population** **I** **stars** **are** **found** mainly **in** **the** galactic **disk**, **Population** II **stars** mostly reside **in** **the** **central** bulge **of** **the** galaxy **and** **in** **the** halo **surrounding** **this** bulge.

**Population** II **stars** **date** **to** **the** **early** **stages** **of** **the** **universe**. **Formed** **when** **the** cosmos **was** **filled** **with** **hydrogen** **and** helium **gases**, **they** initially **contained** virtually **no** **heavy** elements. **They** **shine** **until** **their** fusible **material** **is** exhausted. **When** **Population** II **stars** **die**, **their** **material** **is** **spread** **out** **into** **space**. **Some** **of** **this** **dust** **is** **eventually** incorporated **into** newly **formed** **Population** **I** **stars**. **Though** **Population** **I** **stars** **consist** mostly **of** **hydrogen** **and** helium **gas**, **they** **also** **contain** **heavy** elements (heavier **than** helium), **which** comprise **about** 1 **or** 2 **percent** **of** **their** **mass**. **These** heavier **materials** **are** fused **from** **the** lighter elements **that** **the** **stars** **have** **collected**. **Thus**, **Population** **I** **stars** **contain** **material** **that** **once** **belonged** **to** **stars** **from** previous **generations**. **The** **Sun** **is** **a** **good** **example** **of** **a** **Population** **I** **star**.

**What** **will** **happen** **when** **the** **Sun** **dies**? **In** **several** **billion** **years**, **our** **mother** **star** **will** **burn** **much** brighter. **It** **will** expend **more** **and** **more** **of** **its** **nuclear** **fuel**, **until** **little** **is** **left** **of** **its** original **hydrogen**. **Then**, **at** **some** **point** **in** **the** **far** **future**, **all** **nuclear** reactions **in** **the** **Sun**’s center **will** cease.

**Once** **the** **Sun** **passes** **into** **its** “postnuclear” phase, **it** **will** **separate** effectively **into** **two** **different** regions: an inner **zone** **and** an **outer** **zone**. **While** **no** **more** **hydrogen** **fuel** **will** **remain** **in** **the** inner **zone**, **there** **will** **be** **a** **small** **amount** **left** **in** **the** **outer** **zone**. Rapidly, **changes** **will** **begin** **to** **take** **place** **that** **will** **serve** **to** **tear** **the** **Sun** **apart**. **The** inner **zone**, **its** **nuclear** **fires** **no** longer **burning**, **will** **begin** **to** collapse **under** **the** **influence** **of** **its** **own** **weight** **and** **will** contract **into** **a** **tiny** **hot** core, dense **and** dim. An **opposite** fate **will** await **the** **outer** region, **a** loosely **held**-**together** **ball** **of** **gas**. **A** **shock** **wave** **caused** **by** **the** inner **zone**’s contraction **will** **send** ripples **through** **the** **dying** **star**, **pushing** **the** stellar exterior’s **material** farther **and** farther **outward**. **The** **outer** **envelope** **will** **then** **grow** rapidly, **increasing**, **in** **a** **short** **interval**, **hundreds** **of** **times** **in** **size**. **As** **it** **expands**, **it** **will** **cool** **down** **by** **thousands** **of** **degrees**. **Eventually**, **the** **Sun** **will** **become** **a** **red** giant **star**, **cool** **and** **bright**. **It** **will** **be** **so** **large** **that** **it** **will** occupy **the** **whole** **space** **that** **used** **to** **be** **the** **Earth**’s **orbit** **and** **so** **brilliant** **that** **it** **would** **be** **able** **to** **be** **seen** **with** **the** naked **eye** **thousands** **of** **light**-**years** **away**. **It** **will** **exist** **that** **way** **for** **millions** **of** **years**, **gradually** releasing **the** **material** **of** **its** **outer** **envelope** **into** **space**. Finally, **nothing** **will** **be** **left** **of** **the** gaseous exterior **of** **the** **Sun**; **all** **that** **will** **remain** **will** **be** **the** **hot**, **white** core. **The** **Sun** **will** **have** **become** **a** **white** dwarf **star**. **The** core **will** **shrink**, **giving** **off** **the** **last** **of** **its** energy, **and** **the** **Sun** **will** finally **die**.

count: 208

# Official 17-Passage 03 Symbiotic Relationships

**A** symbiotic **relationship** **is** an interaction **between** **two** **or** **more** species **in** **which** **one** species **lives** **in** **or** **on** **another** species. **There** **are** **three** **main** **types** **of** symbiotic **relationships**: parasitism, commensalism, **and** mutualism. **The** **first** **and** **the** **third** **can** **be** **key** factors **in** **the** structure **of** **a** biological community; **that** **is**, **all** **the** **populations** **of** organisms **living** **together** **and** potentially interacting **in** **a** **particular** **area**.

Parasitism **is** **a** **kind** **of** predator-prey **relationship** **in** **which** **one** organism, **the** parasite, derives **its** **food** **at** **the** **expense** **of** **its** symbiotic **associate**, **the** **host**. Parasites **are** **usually** smaller **than** **their** **hosts**. An **example** **of** **a** parasite **is** **a** tapeworm **that** **lives** **inside** **the** intestines **of** **a** larger **animal** **and** **absorbs** nutrients **from** **its** **host**. **Natural** selection **the** **process** **that** **results** **in** **the** **survival** **of** individuals **or** **groups** **best** **adjusted** **to** **the** **conditions** **under** **which** **they** **live** favors **the** parasites **that** **are** **best** **able** **to** **find** **and** **feed** **on** **hosts**. **At** **the** **same** **time**, defensive **abilities** **of** **hosts** **are** **also** **selected** **for**. **As** an **example**, **plants** **make** **chemicals** toxic **to** fungal **and** bacterial parasites, **along** **with** **ones** toxic **to** predatory **animals** (**sometimes** **they** **are** **the** **same** **chemicals**). **In** vertebrates, **the** immune **system** **provides** **a** multiple defense **against** internal parasites.

**At** **times**, **it** **is** actually **possible** **to** **watch** **the** **effects** **of** **natural** selection **in** **host**-parasite **relationships**. **For** **example**, **Australia** **during** **the** 1940’s **was** overrun **by** **hundreds** **of** **millions** **of** **European** **rabbits**. **The** **rabbits** **destroyed** **huge** expanses **of** **Australia** **and** threatened **the** **sheep** **and** **cattle** **industries**. **In** 1950, myxoma **virus**, **a** parasite **that** **affects** **rabbits**, **was** **deliberately** **introduced** **into** **Australia** **to** **control** **the** **rabbit** **population**. **Spread** rapidly **by** mosquitoes, **the** **virus** devastated **the** **rabbit** **population**. **The** **virus** **was** **less** deadly **to** **the** offspring **of** **surviving** **rabbits**, **however**, **and** **it** **caused** **less** **and** **less** **harm** **over** **the** **years**. Apparently, genotypes (**the** genetic **make**-**up** **of** an organism) **in** **the** **rabbit** **population** **were** **selected** **that** **were** **better** **able** **to** **resist** **the** parasite. **Meanwhile**, **the** deadliest strains **of** **the** **virus** perished **with** **their** **hosts** **as** **natural** selection favored strains **that** **could** infect **hosts** **but** **not** **kill** **them**. **Thus**, **natural** selection stabilized **this** **host**-parasite **relationship**.

**In** contrast **to** parasitism, **in** commensalism, **one** **partner** **benefits** **without** significantly **affecting** **the** **other**. **Few** **cases** **of** **absolute** commensalism **probably** **exist**, **because** **it** **is** unlikely **that** **one** **of** **the** **partners** **will** **be** completely unaffected. Commensal **associations** **sometimes** involve **one** species’ **obtaining** **food** **that** **is** inadvertently **exposed** **by** **another**. **For** instance, **several** **kinds** **of** **birds** **feed** **on** **insects** flushed **out** **of** **the** **grass** **by** grazing **cattle**. **It** **is** **difficult** **to** **imagine** **how** **this** **could** **affect** **the** **cattle**, **but** **the** **relationship** may **help** **or** hinder **them** **in** **some** **way** **not** **yet** recognized.

**The** **third** **type** **of** symbiosis, mutualism, **benefits** **both** **partners** **in** **the** **relationship**. Legume **plants** **and** **their** nitrogen-**fixing** **bacteria**, **and** **the** interactions **between** **flowering** **plants** **and** **their** pollinators, **are** **examples** **of** mutualistic **association**. **In** **the** **first** **case**, **the** **plants** **provide** **the** **bacteria** **with** carbohydrates **and** **other** organic compounds, **and** **the** **bacteria** **have** enzymes **that** **act** **as** catalysts **that** **eventually** **add** nitrogen **to** **the** **soil**, enriching **it**. **In** **the** **second** **case**, pollinators (**insects**, **birds**) **obtain** **food** **from** **the** **flowering** **plant**, **and** **the** **plant** **has** **its** pollen **distributed** **and** **seeds** dispersed **much** **more** efficiently **than** **they** **would** **be** **if** **they** **were** **carried** **by** **the** **wind** **only**. **Another** **example** **of** mutualism **would** **be** **the** bull’s horn acacia **tree**, **which** **grows** **in** **Central** **and** **South** **America**. **The** **tree** **provides** **a** **place** **to** **live** **for** **ants** **of** **the** genus Pseudomyrmex. **The** **ants** **live** **in** **large**, hollow thorns **and** **eat** **sugar** **secreted** **by** **the** **tree**. **The** **ants** **also** **eat** **yellow** structures **at** **the** **tip** **of** leaflets; **these** **are** protein **rich** **and** **seem** **to** **have** **no** **function** **for** **the** **tree** **except** **to** **attract** **ants**. **The** **ants** **benefit** **the** **host** **tree** **by** **attacking** virtually **anything** **that** **touches** **it**. **They** sting **other** **insects** **and** **large** herbivores (**animals** **that** **eat** **only** **plants**) **and** **even** clip **surrounding** vegetation **that** **grows** **near** **the** **tree**. **When** **the** **ants** **are** **removed**, **the** **trees** **usually** **die**, **probably** **because** herbivores **damage** **them** **so** **much** **that** **they** **are** **unable** **to** **compete** **with** **surrounding** vegetation **for** **light** **and** **growing** **space**.

**The** **complex** interplay **of** species **in** symbiotic **relationships** highlights an **important** **point** **about** communities: **Their** structure **depends** **on** **a** **web** **of** **diverse** **connections** **among** organisms.

count: 208

# Official 44-Passage 02 The Use of the Camera Obscura

**The** precursor **of** **the** **modern** **camera**, **the** **camera** obscura **is** **a** darkened enclosure **into** **which** **light** **is** **admitted** **through** **a** lens **in** **a** **small** **hole**. **The** image **of** **the** illuminated **area** **outside** **the** enclosure **is** **thrown** upside **down** **as** **if** **by** **magic** **onto** **a** **surface** **in** **the** darkened enclosure. **This** **technique** **was** **known** **as** **long** **ago** **as** **the** **fifth** **century** B.C. **in** **China**. Aristotle **also** **experimented** **with** **it** **in** **the** **fourth** **century** B.C., **and** Leonardo da Vinci **described** **it** **in** **his** **notebooks** **in** 1490. **In** 1558 Giovanni Battista Della Porta **wrote** **in** **his** **twenty**-volume **work** Magia naturalis (**meaning** “**natural** **magic**”) **instructions** **for** **adding** **a** convex lens **to** **improve** **the** **quality** **of** **the** image **thrown** **against** **a** canvas **or** panel **in** **the** darkened **area** **where** **its** **outlines** **could** **be** traced. **Later**, **portable** **camera** obscuras **were** **developed**, **with** interior **mirrors** **and** **drawing** **tables** **on** **which** **the** **artist** **could** trace **the** image. **For** **the** **artist**, **this** **technique** **allows** **forms** **and** linear perspective **to** **be** **drawn** precisely **as** **they** **would** **be** **seen** **from** **a** **single** viewpoint. **Mirrors** **were** **also** **used** **to** reverse **the** **projected** images **to** **their** original **positions**.

**Did** **some** **of** **the** **great** **masters** **of** **painting**, **then**, trace **their** images **using** **a** **camera** obscura? **Some** **art** historians **are** **now** **looking** **for** clues **of** **artists**’ **use** **of** **such** devices. **One** **of** **the** **artists** **whose** **paintings** **are** **being** **analyzed** **from** **this** **point** **of** **view** **is** **the** **great** Dutch **master**, Jan Vermeer, **who** **lived** **from** 1632 **to** 1675 **during** **the** **flowering** **of** **art** **and** **science** **in** **the** Netherlands, **including** **the** **science** **of** optics. Vermeer **produced** **only** **about** 30 **known** **paintings**, **including** **his** **famous** **The** **Art** **of** **Painting**. **The** **room** **shown** **in** **it** closely **resembles** **the** **room** **in** **other** Vermeer **paintings**, **with** **lighting** **coming** **from** **a** **window** **on** **the** **left**, **the** **same** **roof** **beams**, **and** **similar** **floor** tiles, **suggesting** **that** **the** **room** **was** **fitted** **with** **a** **camera** obscura **on** **the** **side** **in** **the** foreground. **The** **map** **hung** **on** **the** **opposite** **wall** **was** **a** **real** **map** **in** Vermeer’s **possession**, reproduced **in** **such** faithful detail **that** **some** **kind** **of** tracery **is** **suspected**. **When** **one** **of** Vermeer’s **paintings** **was** X-**rayed**, **it** **did** **not** **have** **any** preliminary sketches **on** **the** canvas **beneath** **the** **paint**, **but** **rather** **the** **complete** image **drawn** **in** **black** **and** **white** **without** **any** **trial** sketches. Vermeer **did** **not** **have** **any** **students**, **did** **not** **keep** **any** **records**, **and** **did** **not** **encourage** **anyone** **to** **visit** **his** **studio**, **facts** **that** **can** **be** interpreted **as** **protecting** **his** **secret** **use** **of** **a** **camera** obscura.

**In** **recent** **times** **the British** **artist** David Hockney **has** **published** **his** investigations **into** **the** **secret** **use** **of** **the** **camera** obscura, claiming **that** **for** **up** **to** 400 **years**, **many** **of** **Western** **art**’s **great** **masters** **probably** **used** **the** device **to** **produce** **almost** photographically realistic details **in** **their** **paintings**. **He** **includes** **in** **this** **group** Caravaggio, Hans Holbein, Leonardo da Vinci, Diego Velázquez, Jean-Auguste-Dominique Ingres, Agnolo Bronzino, **and** Jan van Eyck. **From** an **artist**’s **point** **of** **view**, Hockney **observed** **that** **a** **camera** obscura compresses **the** complicated **forms** **of** **a** **three**-dimensional **scene** **into** **two**-dimensional **shapes** **that** **can** **easily** **be** traced **and** **also** **increases** **the** contrast **between** **light** **and** **dark**, **leading** **to** **the** chiaroscuroartistic **term** **for** **a** contrast **between** **light** **and** **dark** **effect** **seen** **in** **many** **of** **these** **paintings**. **In** Jan van Eyck’s **The** **Marriage** **of** Giovanni Arnolfini **and** Giovanna Cenami, **the** complicated foreshorteninga **technique** **for** **representing** an image **in** **art** **that** **makes** **it** **appear** **to** recede **in** **space** **in** **the** chandelier **and** **the** intricate detail **in** **the** **bride**’s **garments** **are** **among** **the** clues **that** Hockney **thinks** **point** **to** **the** **use** **of** **the** **camera** obscura.

**So** **what** **are** **we** **to** **conclude**? **If** **these** **artists** **did** **use** **a** **camera** obscura, **does** **that** diminish **their** stature? Hockney **argues** **that** **the** **camera** obscura **does** **not** **replace** artistic **skill** **in** **drawing** **and** **painting**. **In** **experimenting** **with** **it**, **he** **found** **that** **it** **is** actually **quite** **difficult** **to** **use** **for** **drawing**, **and** **he** speculates **that** **the** **artists** **probably** **combined** **their** observations **from** **life** **with** tracing **of** **shapes**.

count: 208

# Official 52-Passage 02 Natufian Culture

**In** **the** archaeological **record** **of** **the** Natufian **period**, **from** **about** 12,500 **to** 10,200 **years** **ago**, **in** **the** **part** **of** **the** **Middle East** **East** **known** **as** **the** Levant―roughly **east** **of** **the** Mediterranean **and** **north** **of** **the** Arabian Peninsula―**we** **see** **clear** **evidence** **of** **agricultural** **origins**. **The** **stone** **tools** **of** **the** Natufians **included** **many** sickle-**shaped** **cutting** blades **that** **show** **a** **pattern** **of** **wear** **characteristic** **of** cereal **harvesting**. **Also**, querns (**hand** mills) **and** **other** **stone** **tools** **used** **for** **processing** **grain** **occur** **in** abundance **at** Natufian sites, **and** **many** **such** **tools** **show** **signs** **of** **long**, intensive **use**. **Along** **with** **the** sickle blades **are** **many** grinding **stones**, primarily mortars **and** pestles **of** limestone **or** basalt. **There** **is** **also** **evidence** **that** **these** **heavy** grinding **stones** **were** **transported** **over** **long** **distances**, **more** **than** 30 kilometers **in** **some** **cases**, **and** **this** **is** **not** **something** **known** **to** **have** **been** **done** **by** **people** **of** preceding **periods**. Fishhooks **and** **weights** **for** **sinking** **fishing** **nets** attest **to** **the** **growing** **importance** **of** **fish** **in** **the** **diet** **in** **some** **areas**. **Stone** vessels indicate an **increased** **need** **for** **containers**, **but** **there** **is** **no** **evidence** **of** Natufian **clay** **working** **or** pottery. **Studies** **of** **the** **teeth** **of** Natufians **also** strongly **suggest** **that** **these** **people** specialized **in** **collecting** cereals **and** may **have** **been** cultivating **them** **and** **in** **the** **process** **of** domesticating **them**, **but** **they** **were** **also** **still** **hunter**-foragers **who** intensively **hunted** gazelle **and** **deer** **in** **more** lush **areas** **and** **wild** **goats** **and** equids **in** **more** arid **zones**.

**The** Natufians **had** **a** **different** **settlement** **pattern** **from** **that** **of** **their** predecessors. **Some** **of** **their** **base** **camps** **were** **far** larger (**over** 1,000 **square** meters) **than** **any** **of** **those** **belonging** **to** earlier **periods**, **and** **they** may **have** **lived** **in** **some** **of** **these** **camps** **for** **half** **the** **year** **or** **even** **more**. **In** **some** **of** **the** **camps**, **people** **made** foundations **and** **other** architectural elements **out** **of** limestone **blocks**. **Trade** **in** shell, obsidian, **and** **other** commodities **seems** **to** **have** **been** **on** **the** **rise**, **and** anthropologists **suspect** **that** **the** **exchange** **of** perishables (**such** **as** **skins**, foodstuffs) **and** **salt** **was** **also** **on** **the** **increase**. **With** **the** **growing** **importance** **of** **wild** cereals **in** **the** **diet**, **salt** **probably** **became** **for** **the** **first** **time** **a** **near** necessity: **people** **who** **eat** **a** **lot** **of** **meat** **get** **many** essential **salts** **from** **this** **diet**, **but** **diets** **based** **on** cereals **can** **be** deficient **in** **salts**. **Salt** **was** **probably** **also** **important** **as** **a** **food** preservative **in** **early** **villages**.

**As** **always**, **there** **is** **more** **to** **a** **major** cultural **change** **than** **simply** **a** shift **in** economics. **The** Natufians **made** (**and** presumably **wore**) beads **and** pendants **in** **many** **materials**, **including** gemstones **and** marine shells **that** **had** **to** **be** **imported**, **and** **it** **is** **possible** **that** **this** ornamentation actually **reflects** **a** **growing** **sense** **of** ethnic **identity** **and** **perhaps** **some** **differences** **in** **personal** **and** **group** **status**. Cleverly **carved** figurines **of** **animals**, **women**, **and** **other** **subjects** **occur** **in** **many** sites, **and** Natufian **period** **cave** **paintings** **have** **been** **found** **in** Anatolia, Syria, **and** Iran. **More** **than** 400 Natufian **burials** **have** **been** **found**, **most** **of** **them** **simple** graves **set** **in** **house** **floors**. **As** archaeologist Belfer-Cohen **notes**, **these** **burials** may **reflect** an **ancestor** cult **and** **a** **growing** **sense** **of** community emotional **ties** **and** attachment **to** **a** **particular** **place**, **and** **toward** **the** **end** **of** **the** Natufian **period**, **people** **in** **this** **area** **were** **making** **a** **strict** **separation** **between** **living** **quarters** **and** **burial** **grounds**. **In** contrast **with** **the** Pleistocene **cultures** **of** **the** Levant, Natufian **culture** **appears** **to** **have** **experienced** considerable **social** **change**.

**The** **question** **of** **why** **the** Natufians **differed** **from** **their** predecessors **in** **these** **and** **other** **ways** **and** **why** **they** **made** **these** **first** **steps** **toward** **farming** **as** **a** **way** **of** **life** **remains** unclear. **There** **were** **climate** **changes**, **of** **course**, **and** **growing** aridity **and** **rising** **population** densities may **have** **forced** **them** **to** intensify **the** exploitation **of** cereals, **which** **in** **turn** **might** **have** stimulated **the** **development** **of** sickles **and** **other** **tools** **and** **the** **permanent** communities **that** **make** **agriculture** efficient. **But** precisely **how** **these** factors interacted **with** **others** **at** **play** **is** poorly **understood**.

count: 207

# Official 25-Passage 03 The Evolutionary Origin of Plants

**The** evolutionary **history** **of** **plants** **has** **been** **marked** **by** **a** series **of** **adaptations**. **The** **ancestors** **of** **plants** **were** photosynthetic **single**-**celled** organisms **probably** **similar** **to** **today**’s algae. **Like** **modern** algae, **the** organisms **that** **gave** **rise** **to** **plants** presumably **lacked** **true** **roots**, stems, **leaves**, **and** **complex** reproductive structures **such** **as** **flowers**. **All** **of** **these** features **appeared** **later** **in** **the** evolutionary **history** **of** **plants**. **Of** **today**’s **different** **groups** **of** algae, **green** algae **are** **probably** **the** **most** **similar** **to** ancestral **plants**. **This** supposition stems **from** **the** **close** phylogenetic (**natural** evolutionary) **relationship** **between** **the** **two** **groups**. DNA comparisons **have** **shown** **that** **green** algae **are** **plants**’ closest **living** **relatives**. **In** **addition**, **other** **lines** **of** **evidence** **support** **the** hypothesis **that** **land** **plants** evolved **from** ancestral **green** algae: **green** algae **used** **the** **same** **type** **of** chlorophyll **and** accessory pigments **in** photosynthesis **as** **do** **land** **plants**. **This** **would** **not** **be** **true** **of** **red** **or** **brown** algae. **Green** algae **store** **food** **as** starch, **as** **do** **land** **plants** **and** **have** **cell** **walls** **made** **of** cellulose, **similar** **in** **composition** **to** **those** **of** **land** **plants**. **Again**, **the** **food** **storage** **and** **cell** **wall** molecules **of** **red** **and** **brown** algae **are** **different**.

**Today** **green** algae **live** mainly **in** freshwater, **suggesting** **that** **their** **early** evolutionary **history** may **have** **occurred** **in** freshwater habitats. **If** **so**, **the** **green** algae **would** **have** **been** **subjected** **to** environmental **pressures** **that** **resulted** **in** **adaptations** **that** enhanced **their** **potential** **to** **give** **rise** **to** **land**-dwelling organisms.

**The** environmental **conditions** **of** freshwater habitats, **unlike** **those** **of** **ocean** habitats, **are** highly variable. **Water** **temperature** **can** fluctuate seasonally **or** **even** **daily**, **and** **changing** **levels** **of** **rainfall** **can** **lead** **to** fluctuations **in** **the** concentration **of** **chemicals** **in** **the** **water** **or** **even** **to** **periods** **in** **which** **the** aquatic habitat **dries** **up**. **Ancient** freshwater **green** algae must **have** evolved features **that** enabled **them** **to** withstand **extremes** **of** **temperature** **and** **periods** **of** dryness. **These** **adaptations** **served** **their** descendants **well** **as** **they** invaded **land**.

**The** terrestrial **world** **is** **green** **now**, **but** **it** **did** **not** **start** **out** **that** **way**. **When** **plants** **first** **made** **the** transition ashore **more** **than** 400 **million** **years** **ago**, **the** **land** **was** barren **and** desolate, inhospitable **to** **life**. **From** **a** **plant**’s evolutionary viewpoint, **however**, **it** **was** **also** **a** **land** **of** opportunity, **free** **of** **competitors** **and** predators **and** **full** **of** **carbon** **dioxide** **and** **sunlight** (**the** **raw** **materials** **for** photosynthesis, **which** **are** **present** **in** **far** higher concentrations **in** **air** **than** **in** **water**). **So** **once** **natural** selection **had** **shaped** **the** **adaptations** **that** **helped** **plants** **overcome** **the** obstacles **to** terrestrial **living**, **plants** prospered **and** diversified.

**When** **plants** **pioneered** **the** **land**, **they** **faced** **a** **range** **of** **challenges** posed **by** terrestrial **environments**. **On** **land**, **the** supportive buoyancy **of** **water** **is** **missing**, **the** **plant** **is** **no** longer **bathed** **in** **a** nutrient solution, **and** **the** **air** **tends** **to** **dry** **things** **out**. **These** **conditions** favored **the** **evolution** **of** structures **that** **support** **the** body, vessels **that** **transport** **water** **and** nutrients **to** **all** **parts** **of** **the** **plant**, **and** structures **that** conserve **water**. **The** **resulting** **adaptations** **to** **dry** **land** **include** **some** structural features **that** **arose** **early** **in** **plant** **evolution**; **now** **these** features **are** **common** **to** virtually **all** **land** **plants**. **They** **include** **roots** **or** rootlike structures, **a** waxy cuticle **that** **covers** **the** **surfaces** **of** **leaves** **and** stems **and** **limits** **the** evaporation **of** **water**, **and** pores **called** stomata **in** **leaves** **and** stems **that** **allow** **gas** **exchange** **but** **close** **when** **water** **is** scarce, **thus** **reducing** **water** **loss**. **Other** **adaptations** **occurred** **later** **in** **the** transition **to** terrestrial **life** **and** **are** **now** **widespread** **but** **not** **universal** **among** **plants**. **These** **include** **conducting** vessels **that** **transport** **water** **and** **minerals** **upward** **from** **the** **roots** **and** **that** **move** photosynthetic **products** **from** **the** **leaves** **to** **the** **rest** **of** **the** **plant** body **and** **the** stiffening substance lignin, **which** **supports** **the** **plant** body, **helping** **it** **expose** **maximum** **surface** **area** **to** **sunlight**.

**These** **adaptations** **allowed** an **increasing** diversity **of** **plant** **forms** **to** **exploit** **dry** **land**. **Life** **on** **land**, **however**, **also** **required** **new** **methods** **of** **transporting** sperm **to** **eggs**. **Unlike** aquatic **and** marine **forms**, **land** **plants** cannot **always** **rely** **on** **water** currents **to** **carry** **their** **sex** **cells** **and** disperse **their** fertilized **eggs**. **So** **the** **most** **successful** **groups** **of** **land** **plants** **are** **those** **that** evolved **methods** **of** fertilized **sex** **cell** dispersal **that** **are** **independent** **of** **water** **and** structures **that** **protect** **developing** embryos **from** **drying** **out**. **Protected** embryos **and** waterless dispersal **of** **sex** **cells** **were** **achieved** **with** **the** **origin** **of** **seed** **plants** **and** **the** **key** evolutionary innovations **that** **they** **introduced**: pollen, **seeds**, **and**, **later**, **flowers** **and** **fruits**.

count: 207

# Official 03-Passage 02 Depletion of the Ogallala Aquifer

**The** **vast** grasslands **of** **the** **High** **Plains** **in** **the** **central** **United** **States** **were** **settled** **by** **farmers** **and** ranchers **in** **the** 1880’s. **This** region **has** **a** semiarid **climate**, **and** **for** 50 **years** after **its** **settlement**, **it** **supported** **a** **low**-intensity **agricultural** economy **of** **cattle** ranching **and** **wheat** **farming**. **In** **the** **early** **twentieth** **century**, **however**, **it** **was** **discovered** **that** **much** **of** **the** **High** **Plains** **was** underlain **by** **a** **huge** aquifer (**a** **rock** layer **containing** **large** **quantities** **of** groundwater). **This** aquifer **was** **named** **the** Ogallala aquifer after **the** Ogallala Sioux Indians, **who** **once** inhabited **the** region.

**The** Ogallala aquifer **is** **a** sandstone formation **that** underlies **some** 583,000 **square** kilometers **of** **land** extending **from** northwestern Texas **to** **southern** **South** Dakota. **Water** **from** **rains** **and** melting **snows** **has** **been** **accumulating** **in** **the** Ogallala **for** **the** **past** 30,000 **years**. Estimates indicate **that** **the** aquifer **contains** **enough** **water** **to** **fill** **Lake** Huron, **but** **unfortunately**, **under** **the** semiarid climatic **conditions** **that** presently **exist** **in** **the** region, **rates** **of** **addition** **to** **the** aquifer **are** minimal, **amounting** **to** **about** **half** **a** centimeter **a** **year**.

**The** **first** **wells** **were** **drilled** **into** **the** Ogallala **during** **the** drought **years** **of** **the** **early** 1930’s. **The** ensuing **rapid** expansion **of** **irrigation** **agriculture**, **especially** **from** **the** 1950’s onward, **transformed** **the** economy **of** **the** region. **More** **than** 100,000 **wells** **now** **tap** **the** Ogallala. **Modern** **irrigation** devices, **each** capable **of** **spraying** 4.5 **million** liters **of** **water** **a** **day**, **have** **produced** **a** landscape dominated **by** geometric **patterns** **of** circular **green** **islands** **of** **crops**. Ogallala **water** **has** enabled **the** **High** **Plains** region **to** **supply** significant **amounts** **of** **the** **cotton**, sorghum, **wheat**, **and** **corn** **grown** **in** **the** **United** **States**. **In** **addition**, 40 **percent** **of** **American** **grain**-**fed** **beef** **cattle** **are** fattened **here**.

**This** unprecedented **development** **of** **a** finite groundwater resource **with** an **almost** negligible **natural** recharge **rate**—**that** **is**, virtually **no** **natural** **water** source **to** replenish **the** **water** **supply**—**has** **caused** **water** **tables** **in** **the** region **to** **fall** drastically. **In** **the** 1930’s, **wells** encountered plentiful **water** **at** **a** **depth** **of** **about** 15 meters; currently, **they** must **be** **dug** **to** **depths** **of** 45 **to** 60 meters **or** **more**. **In** **places**, **the** **water** **table** **is** **declining** **at** **a** **rate** **of** **a** meter **a** **year**, necessitating **the** periodic deepening **of** **wells** **and** **the** **use** **of** **ever**-**more**-**powerful** **pumps**. **It** **is** estimated **that** **at** current withdrawal **rates**, **much** **of** **the** aquifer **will** **run** **dry** **within** 40 **years**. **The** **situation** **is** **most** critical **in** Texas, **where** **the** **climate** **is** driest, **the** greatest **amount** **of** **water** **is** **being** **pumped**, **and** **the** aquifer **contains** **the** **least** **water**. **It** **is** **projected** **that** **the** **remaining** Ogallala **water** **will**, **by** **the** **year** 2030, **support** **only** 35 **to** 40 **percent** **of** **the** **irrigated** acreage **in** Texas **that** **it** **supported** **in** 1980.

**The** reaction **of** **farmers** **to** **the** inevitable depletion **of** **the** Ogallala varies. **Many** **have** **been** **attempting** **to** conserve **water** **by** **irrigating** **less** frequently **or** **by** **switching** **to** **crops** **that** **require** **less** **water**. **Others**, **however**, **have** **adopted** **the** philosophy **that** **it** **is** **best** **to** **use** **the** **water** **while** **it** **is** **still** economically profitable **to** **do** **so** **and** **to** **concentrate** **on** **high**-**value** **crops** **such** **as** **cotton**. **The** incentive **of** **the** **farmers** **who** **wish** **to** conserve **water** **is** **reduced** **by** **their** **knowledge** **that** **many** **of** **their** neighbors **are** **profiting** **by** **using** **great** **amounts** **of** **water**, **and** **in** **the** **process** **are** **drawing** **down** **the** **entire** region’s **water** **supplies**.

**In** **the** **face** **of** **the** upcoming **water** **supply** crisis, **a** **number** **of** grandiose schemes **have** **been** **developed** **to** **transport** **vast** **quantities** **of** **water** **by** **canal** **or** pipeline **from** **the** Mississippi, **the** Missouri, **or** **the** Arkansas **rivers**. **Unfortunately**, **the** **cost** **of** **water** **obtained** **through** **any** **of** **these** schemes **would** **increase** **pumping** **costs** **at** **least** tenfold, **making** **the** **cost** **of** **irrigated** **agricultural** **products** **from** **the** region uncompetitive **on** **the** **national** **and** **international** **markets**. Somewhat **more** **promising** **have** **been** **recent** **experiments** **for** releasing capillary **water** (**water** **in** **the** **soil**) **above** **the** **water** **table** **by** injecting compressed **air** **into** **the** **ground**. **Even** **if** **this** **process** **proves** **successful**, **however**, **it** **would** **almost** triple **water** **costs**. Genetic **engineering** **also** may **provide** **a** partial solution, **as** **new** strains **of** drought-resistant **crops** **continue** **to** **be** **developed**. **Whatever** **the** **final** **answer** **to** **the** **water** crisis may **be**, **it** **is** **evident** **that** **within** **the** **High** **Plains**, **irrigation** **water** **will** **never** **again** **be** **the** **abundant**, inexpensive resource **it** **was** **during** **the** **agricultural** **boom** **years** **of** **the** mid-**twentieth** **century**.

count: 207

# Official 33-Passage 02 Extinction Episodes of the Past

**It** **was** **not** **until** **the** Cambrian **period**, **beginning** **about** 600 **million** **years** **ago**, **that** **a** **great** proliferation **of** macroscopic species **occurred** **on** **Earth** **and** **produced** **a** fossil **record** **that** **allows** us **to** **track** **the** **rise** **and** **fall** **of** biodiversity. **Since** **the** Cambrian **period**, biodiversity **has** generally **risen**, **but** **there** **have** **been** **some** notable exceptions. Biodiversity collapsed dramatically **during** **at** **least** **five** **periods** **because** **of** **mass** extinctions **around** **the** **globe**. **The** **five** **major** **mass** extinctions **receive** **most** **of** **the** **attention**, **but** **they** **are** **only** **one** **end** **of** **a** spectrum **of** extinction **events**. Collectively, **more** species **went** extinct **during** smaller **events** **that** **were** **less** dramatic **but** **more** **frequent**. **The** **best** **known** **of** **the** **five** **major** extinction **events**, **the** **one** **that** **saw** **the** demise **of** **the** **dinosaurs**, **is** **the** Cretaceous-Tertiary extinction.

**Starting** **about** 280 **million** **years** **ago**, reptiles **were** **the** dominant **large** **animals** **in** terrestrial **environments**. **In** **popular** **language** **this** **was** **the** era “**when** **dinosaurs** **ruled** **Earth**,” **with** **a** **wide** **variety** **of** reptile species occupying **many** ecological niches. **However**, **no** **group** **or** species **can** maintain **its** dominance indefinitely, **and** **when**, after **over** 200 **million** **years**, **the** **age** **of** **dinosaurs** **came** **to** **a** dramatic **end** **about** 65 **million** **years** **ago**, mammals **began** **to** flourish, evolving **from** relatively **few** **types** **of** **small** terrestrial **animals** **into** **the** myriad **of** **diverse** species, **including** **bats** **and** **whales**, **that** **we** **know** **today**. Paleontologists label **this** **point** **in** **Earth**’s **history** **as** **the** **end** **of** **the** Cretaceous **period** **and** **the** **beginning** **of** **the** Tertiary **period**, **often** abbreviated **as** **the** K-T **boundary**. **This** **time** **was** **also** **marked** **by** **changes** **in** **many** **other** **types** **of** organisms. Overall, **about** 38 **percent** **of** **the** **families** **of** marine **animals** **were** **lost**, **with** **percentages** **much** higher **in** **some** **groups**. Ammonoid mollusks **went** **from** **being** **very** **diverse** **and** **abundant** **to** **being** extinct. An **extremely** **abundant** **set** **of** planktonic marine **animals** **called** foraminifera largely **disappeared**, **although** **they** rebounded **later**. **Among** **plants**, **the** K-T **boundary** **saw** **a** **sharp** **but** **brief** **rise** **in** **the** abundance **of** **primitive** vascular **plants** **such** **as** ferns, **club** mosses, horsetails, **and** conifers **and** **other** gymnosperms. **The** **number** **of** **flowering** **plants** (angiosperms) **was** **reduced** **at** **this** **time**, **but** **they** **then** **began** **to** **increase** dramatically.

**What** **caused** **these** **changes**? **For** **many** **years** **scientists** **assumed** **that** **a** **cooling** **of** **the** **climate** **was** responsible, **with** **dinosaurs** **being** particularly vulnerable **because**, **like** **modern** reptiles, **they** **were** ectothermic (dependent **on** environmental **heat**, **or** **cold-blooded**). **It** **is** **now** widely **believed** **that** **at** **least** **some** species **of** **dinosaurs** **had** **a** metabolic **rate** **high** **enough** **for** **them** **to** **be** endotherms (**animals** **that** maintain **a** relatively **consistent** body **temperature** **by** generating **heat** internally). Nevertheless, climatic **explanations** **for** **the** K-T extinction **are** **not** **really** **challenged** **by** **the** **idea** **that** **dinosaurs** may **have** **been** endothermic, **because** **even** endotherms **can** **be** **affected** **by** **a** significant **change** **in** **the** **climate**.

**Explanations** **for** **the** K-T extinction **were** revolutionized **in** 1980 **when** **a** **group** **of** **physical** **scientists** **led** **by** Luis Alvarez proposed **that** 65 **million** **years** **ago** **Earth** **was** **struck** **by** **a** 10-kilometer-**wide** meteorite traveling **at** 90,000 kilometers **per** **hour**. **They** **believed** **that** **this** impact generated **a** **thick** **cloud** **of** **dust** **that** **enveloped** **Earth**, **shutting** **out** **much** **of** **the** **incoming** **solar** **radiation** **and** **reducing** **plant** photosynthesis **to** **very** **low** **levels**. **Short**-**term** **effects** **might** **have** **included** **huge** tidal **waves** **and** extensive **fires**. **In** **other** **words**, **a** series **of** **events** **arising** **from** **a** **single** cataclysmic **event** **caused** **the** massive extinctions. Initially, **the** meteorite **theory** **was** **based** **on** **a** **single** **line** **of** **evidence**. **At** locations **around** **the** **globe**, geologists **had** **found** an unusually **high** concentration **of** iridium **in** **the** layer **of** sedimentary **rocks** **that** **was** **formed** **about** 65 **million** **years** **ago**. Iridium **is** an element **that** **is** **usually** uncommon **near** **Earth**’s **surface**, **but** **it** **is** **abundant** **in** **some** meteorites. **Therefore**, Alvarez **and** **his** **colleagues** **concluded** **that** **it** **was** **likely** **that** **the** iridium **in** sedimentary **rocks** **deposited** **at** **the** K-T **boundary** **had** originated **in** **a** giant meteorite **or** asteroid. **Most** **scientists** **came** **to** **accept** **the** meteorite **theory** after **evidence** **came** **to** **light** **that** **a** circular formation, 180 kilometers **in** diameter **and** centered **on** **the** **north** **coast** **of** **the** Yucatán Peninsula, **was** **created** **by** **a** meteorite impact **about** 65 **million** **years** **ago**.

count: 206

# Official 46-Passage 03 Ecosystem Diversity and Stability

**Conservation** biologists **have** **long** **been** **concerned** **that** species extinction **could** **have** significant **consequences** **for** **the** stability **of** **entire** ecosystems—**groups** **of** interacting organisms **and** **the** **physical** **environment** **that** **they** inhabit. An ecosystem **could** **survive** **the** **loss** **of** **some** species, **but** **if** **enough** species **were** **lost**, **the** ecosystem **would** **be** severely degraded. **In** **fact**, **it** **is** **possible** **that** **the** **loss** **of** **a** **single** **important** species **could** **start** **a** cascade **of** extinctions **that** **might** dramatically **change** an **entire** ecosystem. **A** **good** illustration **of** **this** **occurred** after **sea** otters **were** eliminated **from** **some** **Pacific** kelp (**seaweed**) **bed** ecosystems: **the** kelp **beds** **were** practically obliterated **too** **because** **in** **the** **absence** **of** **sea** otter predation, **sea** urchin **populations** **exploded** **and** **consumed** **most** **of** **the** kelp **and** **other** macroalgae.

**It** **is** **usually** claimed **that** species-**rich** ecosystems **tend** **to** **be** **more** **stable** **than** species-**poor** ecosystems. **Three** mechanisms **by** **which** higher diversity **increases** ecosystem stability **have** **been** proposed. **First**, **if** **there** **are** **more** species **in** an ecosystem, **then** **its** **food** **web** **will** **be** **more** **complex**, **with** greater redundancy **among** species **in** **terms** **of** **their** nutritional **roles**. **In** **other** **words**, **in** **a** **rich** **system** **if** **a** species **is** **lost**, **there** **is** **a** **good** **chance** **that** **other** species **will** **take** **over** **its** **function** **as** prey, predator, producer, decomposer, **or** **whatever** **role** **it** **played**. **Second**, **diverse** ecosystems may **be** **less** **likely** **to** **be** invaded **by** **new** species, notably exotics (**foreign** species **living** **outside** **their** **native** **range**), **that** **would** disrupt **the** ecosystem’s structure **and** **function**. **Third**, **in** **a** species-**rich** ecosystem, **diseases** may **spread** **more** slowly **because** **most** species **will** **be** relatively **less** **abundant**, **thus** **increasing** **the** **average** **distance** **between** individuals **of** **the** **same** species **and** hampering **disease** transmission **among** individuals.

**Scientific** **evidence** **to** illuminate **these** **ideas** **has** **been** **slow** **in** **coming**, **and** **many** **shadows** **remain**. **One** **of** **the** **first** **studies** **to** **provide** **data** **supporting** **a** **relationship** **between** diversity **and** stability **examined** **how** grassland **plants** **responded** **to** **a** drought. Researchers D. Tilman **and** J.**A**. **Downing** **used** **the** ratio **of** **above**-**ground** biomass **in** 1988 (after **two** **years** **of** drought) **to** **that** **in** 1986 (predrought) **in** 207 **plots** **in** **a** grassland **field** **in** **the** Cedar Creek **Natural** **History** **Area** **in** Minnesota **as** an index **of** ecosystem response **to** disruption **by** drought. **In** an **experiment** **that** **began** **in** 1982, **they** **compared** **these** **values** **with** **the** **number** **of** **plant** species **in** **each** **plot** **and** **discovered** **that** **the** **plots** **with** **a** greater **number** **of** **plant** species **experienced** **a** **less** dramatic reduction **in** biomass. **Plots** **with** **more** **than** **ten** species **had** **about** **half** **as** **much** biomass **in** 1988 **as** **in** 1986, whereas **those** **with** fewer **than** **five** species **only** **produced** roughly **one**-**eighth** **as** **much** biomass after **the** **two**-**year** drought. Apparently, species-**rich** **plots** **were** **likely** **to** **contain** **some** drought-resistant **plant** species **that** **grew** **better** **in** drought **years**, **compensating** **for** **the** **poor** **growth** **of** **less**-tolerant species.

**To** **put** **this** **result** **in** **more** **general** **terms**, **a** species-**rich** ecosystem may **be** **more** **stable** **because** **it** **is** **more** **likely** **to** **have** species **with** **a** **wide** array **of** responses **to** variable **conditions** **such** **as** droughts. Furthermore, **a** species-**rich** ecosystem **is** **more** **likely** **to** **have** species **with** **similar** ecological **functions**, **so** **that** **if** **a** species **is** **lost** **from** an ecosystem, **another** species, **probably** **a** **competitor**, **is** **likely** **to** flourish **and** occupy **its** functional **role**. **Both** **of** **these**, variability **in** responses **and** functional redundancy, **could** **be** **thought** **of** **as** **insurance** **against** disturbances.

**The** Minnesota grassland **research** **has** **been** widely **accepted** **as** **strong** **evidence** **for** **the** diversity-stability **theory**; **however**, **its** findings **have** **been** **questioned**, **and** **similar** **studies** **on** **other** ecosystems **have** **not** **always** **found** **a** positive **relationship** **between** diversity **and** stability. **Clearly**, **this** **is** **a** **complex** issue **that** **requires** further **field** **research** **with** **a** **broad** spectrum **of** ecosystems **and** species: grassland **plants** **and** **computer** **models** **will** **only** **take** us **so** **far**. **In** **the** **end**, despite insightful **attempts** **to** detect **some** **general** **patterns**, **we** may **find** **it** **very** **difficult** **to** **reduce** **this** **topic** **to** **a** **simple**, **universal** **truth**.

count: 204

# Official 22-Passage 03 The Allende Meteorite

Sometime after **midnight** **on** **February** 8, 1969, **a** **large**, **bright** meteor **entered** **Earth**’s **atmosphere** **and** **broke** **into** **thousands** **of** **pieces**, plummeted **to** **the** **ground**, **and** scattered **over** an **area** 50 **miles** **long** **and** 10 **miles** **wide** **in** **the** **state** **of** Chihuahua **in** **Mexico**. **The** **first** meteorite **from** **this** **fall** **was** **found** **in** **the** **village** **of** Pueblito de Allende. **Altogether**, roughly **two** **tons** **of** meteorite fragments **were** **recovered**, **all** **of** **which** **bear** **the** **name** Allende **for** **the** location **of** **the** **first** **discovery**.

Individual specimens **of** Allende **are** **covered** **with** **a** **black**, glassy crust **that** **formed** **when** **their** exteriors melted **as** **they** **were** **slowed** **by** **Earth**’s **atmosphere**. **When** **broken** **open**, Allende **stones** **are** revealed **to** **contain** an assortment **of** **small**, distinctive **objects**, spherical **or** irregular **in** **shape** **and** embedded **in** **a** **dark** gray matrix (binding **material**), **which** **were** **once** constituents **of** **the** **solar** nebula—**the** interstellar **cloud** **of** **gas** **and** **dust** **out** **of** **which** **our** **solar** **system** **was** **formed**.

**The** Allende meteorite **is** **classified** **as** **a** chondrite. Chondrites **take** **their** **name** **from** **the** **Greek** **word** chondros—**meaning** “**seed**”—an allusion **to** **their** **appearance** **as** **rocks** **containing** **tiny** **seeds**. **These** **seeds** **are** actually chondrules: millimeter-**sized** melted droplets **of** silicate **material** **that** **were** **cooled** **into** spheres **of** **glass** **and** crystal. **A** **few** chondrules **contain** **grains** **that** **survived** **the** melting **event**, **so** **these** enigmatic chondrules must **have** **formed** **when** compact **masses** **of** nebular **dust** **were** fused **at** **high** **temperatures**—**approaching** 1,700 **degrees** Celsius—**and** **then** **cooled** **before** **these** **surviving** **grains** **could** melt. **Study** **of** **the** textures **of** chondrules **confirms** **that** **they** **cooled** **rather** quickly, **in** **times** **measured** **in** **minutes** **or** **hours**, **so** **the** **heating** **events** **that** **formed** **them** must **have** **been** localized. **It** **seems** **very** unlikely **that** **large** portions **of** **the** nebula **were** **heated** **to** **such** **extreme** **temperatures**, **and** **huge** nebula **areas** **could** **not** **possibly** **have** **lost** **heat** **so** **fast**. Chondrules must **have** **been** melted **in** **small** **pockets** **of** **the** nebula **that** **were** **able** **to** **lose** **heat** rapidly. **The** **origin** **of** **these** peculiar glassy spheres **remains** an enigma.

Equally perplexing constituents **of** Allende **are** **the** refractory inclusions: irregular **white** **masses** **that** **tend** **to** **be** larger **than** chondrules. **They** **are** composed **of** **minerals** uncommon **on** **Earth**, **all** **rich** **in** calcium, aluminum, **and** titanium, **the** **most** refractory (resistant **to** melting) **of** **the** **major** elements **in** **the** nebula. **The** **same** **minerals** **that** **occur** **in** refractory inclusions **are** **believed** **to** **be** **the** earliest-**formed** substances **to** **have** condensed **out** **of** **the** **solar** nebula. **However**, **studies** **of** **the** textures **of** inclusions reveal **that** **the** **order** **in** **which** **the** **minerals** **appeared** **in** **the** inclusions varies **from** inclusion **to** inclusion, **and** **often** **does** **not** **match** **the** **theoretical** condensation sequence **for** **those** **metals**.

Chondrules **and** inclusions **in** Allende **are** **held** **together** **by** **the** chondrite matrix, **a** **mixture** **of** **fine**-**grained**, mostly silicate **minerals** **that** **also** **includes** **grains** **of** **iron** **metal** **and** **iron** sulfide. **At** **one** **time** **it** **was** **thought** **that** **these** matrix **grains** **might** **be** pristine nebular **dust**, **the** **sort** **of** stuff **from** **which** chondrules **and** inclusions **were** **made**. **However**, detailed **studies** **of** **the** chondrite matrix **suggest** **that** **much** **of** **it**, **too**, **has** **been** **formed** **by** condensation **or** melting **in** **the** nebula, **although** **minute** **amounts** **of** **surviving** interstellar **dust** **are** **mixed** **with** **the** **processed** **materials**.

**All** **these** **diverse** constituents **are** aggregated **together** **to** **form** chondritic meteorites, **like** Allende, **that** **have** **chemical** **compositions** **much** **like** **that** **of** **the** **Sun**. **To** **compare** **the** **compositions** **of** **a** meteorite **and** **the** **Sun**, **it** **is** **necessary** **that** **we** **use** ratios **of** elements **rather** **than** **simply** **the** abundances **of** **atoms**. After **all**, **the** **Sun** **has** **many** **more** **atoms** **of** **any** element, **say** **iron**, **than** **does** **a** meteorite specimen, **but** **the** ratios **of** **iron** **to** silicon **in** **the** **two** **kinds** **of** **matter** **might** **be** comparable. **The** compositional similarity **is** **striking**. **The** **major** **difference** **is** **that** Allende **is** depleted **in** **the** **most** volatile elements, **like** **hydrogen**, **carbon**, **oxygen**, nitrogen, **and** **the** **noble** **gases**, **relative** **to** **the** **Sun**. **These** **are** **the** elements **that** **tend** **to** **form** **gases** **even** **at** **very** **low** **temperatures**. **We** **might** **think** **of** chondrites **as** samples **of** distilled **Sun**, **a** **sort** **of** **solar** sludge **from** **which** **only** **gases** **have** **been** **removed**. **Since** practically **all** **the** **solar** **system**’s **mass** resides **in** **the** **Sun**, **this** similarity **in** **chemistry** **means** **that** chondrites **have** **average** **solar** **system** **composition**, **except** **for** **the** **most** volatile elements; **they** **are** **truly** lumps **of** nebular **matter**, **probably** **similar** **in** **composition** **to** **the** **matter** **from** **which** **planets** **were** assembled.

count: 204

# Official 14-Passage 03 Pastoralism in Ancient Inner Eurasia

Pastoralism **is** **a** lifestyle **in** **which** economic **activity** **is** **based** primarily **on** livestock. Archaeological **evidence** **suggests** **that** **by** 3000 B.C., **and** **perhaps** **even** earlier, **there** **had** emerged **on** **the** steppes **of** Inner Eurasia **the** distinctive **types** **of** pastoralism **that** **were** **to** dominate **the** region’s **history** **for** **several** millennia. **Here**, **the** **horse** **was** **already** **becoming** **the** **animal** **of** prestige **in** **many** regions, **though** **sheep**, **goats**, **and** **cattle** **could** **also** **play** **a** **vital** **role**. **It** **is** **the** **use** **of** **horses** **for** transportation **and** warfare **that** **explains** **why** Inner Eurasian pastoralism **proved** **the** **most** **mobile** **and** **the** **most** militaristic **of** **all** **major** **forms** **of** pastoralism. **The** emergence **and** **spread** **of** pastoralism **had** **a** profound impact **on** **the** **history** **of** Inner Eurasia, **and** **also**, indirectly, **on** **the** **parts** **of** **Asia** **and** **Europe** **just** **outside** **this** **area**. **In** **particular**, pastoralism favors **a** **mobile** lifestyle, **and** **this** mobility **helps** **to** **explain** **the** impact **of** pastoralist **societies** **on** **this** **part** **of** **the** **world**.

**The** mobility **of** pastoralist **societies** **reflects** **their** dependence **on** **animal**-**based** **foods**. **While** agriculturalists **rely** **on** domesticated **plants**, pastoralists **rely** **on** domesticated **animals**. **As** **a** **result**, pastoralists, **like** carnivores **in** **general**, occupy **a** higher **position** **on** **the** **food** **chain**. **All** **else** **being** **equal**, **this** **means** **they** must **exploit** larger **areas** **of** **land** **than** **do** agriculturalists **to** **secure** **the** **same** **amount** **of** **food**, **clothing**, **and** **other** necessities. **So** pastoralism **is** **a** **more** extensive lifeway **than** **farming** **is**. **However**, **the** larger **the** terrain **used** **to** **support** **a** **group**, **the** harder **it** **is** **to** **exploit** **that** terrain **while** **remaining** **in** **one** **place**. **So**, **basic** ecological **principles** imply **a** **strong** **tendency** **within** pastoralist lifeways **toward** nomadism (**a** **mobile** lifestyle). **As** **the** archaeologist Roger Cribb **puts** **it**, “**The** greater **the** **degree** **of** pastoralism, **the** stronger **the** **tendency** **toward** nomadism.” **A** **modern** Turkic nomad **interviewed** **by** Cribb **commented**: “**The** **more** **animals** **you** **have**, **the** farther **you** **have** **to** **move**.”

Nomadism **has** further **consequences**. **It** **means** **that** pastoralist **societies** occupy **and** **can** **influence** **very** **large** territories. **This** **is** particularly **true** **of** **the** **horse** pastoralism **that** emerged **in** **the** Inner Eurasian steppes, **for** **this** **was** **the** **most** **mobile** **of** **all** **major** **forms** **of** pastoralism. **So**, **it** **is** **no** **accident** **that** **with** **the** **appearance** **of** pastoralist **societies** **there** **appear** **large** **areas** **that** **share** **similar** cultural, ecological, **and** **even** linguistic features. **By** **the** **late** **fourth** millennium B.C., **there** **is** **already** **evidence** **of** **large** **culture** **zones** **reaching** **from** **Eastern** **Europe** **to** **the** **western** **borders** **of** Mongolia. **Perhaps** **the** **most** **striking** **sign** **of** mobility **is** **the** **fact** **that** **by** **the** **third** millennium B.C., **most** pastoralists **in** **this** **huge** region **spoke** **related** **languages** ancestral **to** **the** **modern** Indo-**European** **languages**. **The** remarkable mobility **and** **range** **of** pastoral **societies** **explain**, **in** **part**, **why** **so** **many** linguists **have** **argued** **that** **the** Indo-**European** **languages** **began** **their** **astonishing** expansionist career **not** **among** **farmers** **in** Anatolia (**present**-**day** **Turkey**), **but** **among** **early** pastoralists **from** Inner Eurasia. **Such** **theories** imply **that** **the** Indo-**European** **languages** evolved **not** **in** Neolithic (10,000 **to** 3,000 B.C.) Anatolia, **but** **among** **the** foraging communities **of** **the** **cultures** **in** **the** region **of** **the** Don **and** Dnieper **rivers**, **which** **took** **up** stock breeding **and** **began** **to** **exploit** **the** neighboring steppes.

Nomadism **also** **subjects** pastoralist communities **to** **strict** **rules** **of** portability. **If** **you** **are** constantly **on** **the** **move**, **you** cannot **afford** **to** **accumulate** **large** **material** **surpluses**. **Such** **rules** **limit** variations **in** **accumulated** **material** **goods** **between** pastoralist households (**though** **they** may **also** **encourage** **a** **taste** **for** **portable** **goods** **of** **high** **value** **such** **as** **silks** **or** **jewelry**). **So**, **by** **and** **large**, nomadism implies **a** **high** **degree** **of** **self**-sufficiency **and** inhibits **the** **appearance** **of** an extensive **division** **of** labor. Inequalities **of** **wealth** **and** **rank** **certainly** **exist**, **and** **have** **probably** **existed** **in** **most** pastoralist **societies**, **but** **except** **in** **periods** **of** military conquest, **they** **are** normally **too** **slight** **to** generate **the** **stable**, hereditary hierarchies **that** **are** **usually** implied **by** **the** **use** **of** **the** **term** **class**. Inequalities **of** gender **have** **also** **existed** **in** pastoralist **societies**, **but** **they** **seem** **to** **have** **been** softened **by** **the** **absence** **of** **steep** hierarchies **of** **wealth** **in** **most** communities, **and** **also** **by** **the** **requirement** **that** **women** **acquire** **most** **of** **the** **skills** **of** **men**, **including**, **often**, **their** military **skills**.

count: 204

# Official 23-Passage 03 Rock Art of the Australia Aborigines

**Ever** **since** Europeans **first** **explored** **Australia**, **people** **have** **been** **trying** **to** **understand** **the** **ancient** **rock** **drawings** **and** carvings **created** **by** **the** Aborigines, **the** original inhabitants **of** **the** **continent**. **Early** **in** **the** nineteenth **century**, encounters **with** Aboriginal **rock** **art** **tended** **to** **be** infrequent **and** **open** **to** speculative interpretation, **but** **since** **the** **late** nineteenth **century**, awareness **of** **the** extent **and** **variety** **of** **Australian** **rock** **art** **has** **been** **growing**. **In** **the** **latter** **decades** **of** **the** **twentieth** **century** **there** **were** intensified **efforts** **to** **understand** **and** **record** **the** abundance **of** **Australian** **rock** **art**.

**The** **systematic** **study** **of** **this** **art** **is** **a** relatively **new** discipline **in** **Australia**. **Over** **the** **past** **four** **decades** **new** **discoveries** **have** steadily **added** **to** **the** body **of** **knowledge**. **The** **most** significant **data** **have** **come** **from** **a** concentration **on** **three** **major** **questions**. **First**, **what** **is** **the** **age** **of** **Australian** **rock** **art**? **Second**, **what** **is** **its** stylistic **organization** **and** **is** **it** **possible** **to** discern **a** sequence **or** **a** **pattern** **of** **development** **between** **styles**? **Third**, **is** **it** **possible** **to** interpret accurately **the** **subject** **matter** **of** **ancient** **rock** **art**, **bringing** **to** **bear** **all** **available** archaeological **techniques** **and** **the** **knowledge** **of** **present**-**day** Aboriginal informants?

**The** **age** **of** **Australia**’s **rock** **art** **is** constantly **being** revised, **and** earlier datings **have** **been** proposed **as** **the** **result** **of** **new** **discoveries**. Currently, **reliable** **scientific** **evidence** **dates** **the** earliest creation **of** **art** **on** **rock** **surfaces** **in** **Australia** **to** **somewhere** **between** 30,000 **and** 50,000 **years** **ago**. **This** **in** **itself** **is** an **almost** incomprehensible span **of** **generations**, **and** **one** **that** **makes** **Australia**’s **rock** **art** **the** oldest continuous **art** **tradition** **in** **the** **world**.

**Although** **the** remarkable antiquity **of** **Australia**’s **rock** **art** **is** **now** established, **the** sequences **and** **meanings** **of** **its** images **have** **been** widely **debated**. **Since** **the** mid-1970s **a** reasonably **stable** **picture** **has** **formed** **of** **the** **organization** **of** **Australian** **rock** **art**. **In** **order** **to** **create** **a** **sense** **of** structure **to** **this** **picture**, researchers **have** **relied** **on** **a** **distinction** **that** **still** underlies **the** **forms** **of** **much** indigenous **visual** **culture**—**a** **distinction** **between** geometric **and** figurative elements. **Simple** geometric **repeated** **patterns**—**circles**, concentric **circles**, **and** **lines**—constitute **the** iconography (**characteristic** images) **of** **the** earliest **rock**-**art** sites **found** **across** **Australia**. **The** frequency **with** **which** **certain** **simple** motifs **appear** **in** **these** oldest sites **has** **led** **rock**-**art** researchers **to** **adopt** **a** descriptive **term**—**the** Panaramitee **style**—**a** label **which** **takes** **its** **name** **from** **the** extensive **rock** pavements **at** Panaramitee **North** **in** **desert** **South** **Australia**, **which** **are** **covered** **with** motifs pecked **into** **the** **surface**. **Certain** features **of** **these** engravings **lead** **to** **the** **conclusion** **that** **they** **are** **of** **great** **age**—geological **changes** **had** **clearly** **happened** after **the** **designs** **had** **been** **made** **and** **local** Aboriginal informants, **when** **first** **questioned** **about** **them**, **seemed** **to** **know** **nothing** **of** **their** **origins**.Furthermore, **the** **designs** **were** **covered** **with** “**desert** varnish,” **a** glaze **that** **develops** **on** **rock** **surfaces** **over** **thousands** **of** **years** **of** exposure **to** **the** elements. **The** **simple** motifs **found** **at** Panaramitee **are** **common** **to** **many** **rock**-**art** sites **across** **Australia**. **Indeed**, sites **with** engravings **of** geometric **shapes** **are** **also** **to** **be** **found** **on** **the** **island** **of** Tasmania, **which** **was** **separated** **from** **the** **mainland** **of** **the** **continent** **some** 10,000 **years** **ago**.

**In** **the** 1970s, **when** **the** **study** **of** **Australian** archaeology **was** **in** an **exciting** phase **of** **development**, **with** **the** **great** antiquity **of** **rock** **art** **becoming** **clear**, Lesley Maynard, **the** archaeologist **who** **coined** **the** **phrase** “Panaramitee **style**,” **suggested** **that** **a** sequence **could** **be** **determined** **for** **Australian** **rock** **art** **in** **which** **a** geometric **style** **gave** **way** **to** **a** **simple** figurative **style** (**outlines** **of** **figures** **and** **animals**), **followed** **by** **a** **range** **of** **complex** figurative **styles** **that**, **unlike** **the** **pan**-**Australian** geometric **tradition**, **tended** **to** **much** greater regional diversity. **While** **accepting** **that** **this** sequence **fits** **the** archaeological profile **of** **those** sites, **which** **were** occupied continuously **over** **many** **thousands** **of** **years**, **a** **number** **of** writers **have** warned **that** **the** underlying **assumption** **of** **such** **a** sequence—**a** **development** **from** **the** **simple** **and** **the** geometric **to** **the** **complex** **and** naturalistic—obscures **the** cultural continuities **in** Aboriginal **Australia** **in** **which** geometric symbolism **remains** fundamentally **important**. **In** **this** context **the** simplicity **of** **a** geometric motif may **be** **more** **apparent** **than** **real**. Motifs **of** **seeming** simplicity **can** encode **complex** **meanings** **in** Aboriginal **Australia**. **And** **has** **not** **twentieth**-**century** **art** **shown** **that** naturalism **does** **not** necessarily **follow** abstraction **in** **some** **kind** **of** predetermined sequence?

count: 202

# Official 44-Passage 01 From Fish to Terrestrial Vertebrates

**One** **of** **the** **most** significant evolutionary **events** **that** **occurred** **on** **Earth** **was** **the** transition **of** **water**-dwelling **fish** **to** terrestrial tetrapods (**four**-limbed organisms **with** backbones). **Fish** **probably** originated **in** **the** **oceans**, **and** **our** **first** **records** **of** **them** **are** **in** marine **rocks**. **However**, **by** **the** Devonian **Period** (408 **million** **to** 362 **million** **years** **ago**), **they** **had** radiated **into** **almost** **all** **available** aquatic habitats, **including** freshwater settings. **One** **of** **the** **groups** **whose** fossils **are** **especially** **common** **in** **rocks** **deposited** **in** **fresh** **water** **is** **the** lobe-finned **fish**.

**The** freshwater Devonian lobe-finned **fish** rhipidistian crossopterygian **is** **of** **particular** **interest** **to** biologists **studying** tetrapod **evolution**. **These** **fish** **lived** **in** **river** **channels** **and** **lakes** **on** **large** deltas. **The** delta **rocks** **in** **which** **these** fossils **are** **found** **are** commonly **red** **due** **to** oxidized **iron** **minerals**, indicating **that** **the** deltas **formed** **in** **a** **climate** **that** **had** alternate **wet** **and** **dry** **periods**. **If** **there** **were** **periods** **of** drought, **any** **adaptations** **allowing** **the** **fish** **to** **survive** **the** **dry** **conditions** **would** **have** **been** advantageous. **In** **these** rhipidistians, **several** **such** **adaptations** **existed**. **It** **is** **known** **that** **they** **had** **lungs** **as** **well** **as** gills **for** **breathing**. **Cross** **sections** **cut** **through** **some** **of** **the** fossils reveal **that** **the** **mud** **filling** **the** interior **of** **the** carcass **differed** **in** consistency **and** texture **depending** **on** **its** location **inside** **the** **fish**. **These** **differences** **suggest** **a** saclike cavity **below** **the** **front** **end** **of** **the** gut **that** **can** **only** **be** interpreted **as** **a** **lung**. Gills **were** undoubtedly **the** **main** source **of** **oxygen** **for** **these** **fish**, **but** **the** **lungs** **served** **as** an auxiliary **breathing** device **for** gulping **air** **when** **the** **water** **became** **oxygen** depleted, **such** **as** **during** extended **periods** **of** drought. **So**, **these** **fish** **had** **already** evolved **one** **of** **the** prime requisites **for** **living** **on** **land**: **the** **ability** **to** **use** **air** **as** **a** source **of** **oxygen**.

**A** **second** **adaptation** **of** **these** **fish** **was** **in** **the** structure **of** **the** lobe fins. **The** fins **were** **thick**, fleshy, **and** **quite** sturdy, **with** **a** median axis **of** **bone** **down** **the** center. **They** **could** **have** **been** **used** **as** feeble locomotor devices **on** **land**, **perhaps** **good** **enough** **to** **allow** **a** **fish** **to** flop **its** **way** **from** **one** **pool** **of** **water** **that** **was** **almost** **dry** **to** an adjacent **pond** **that** **had** **enough** **water** **and** **oxygen** **for** **survival**. **These** fins **eventually** **changed** **into** **short**, stubby **legs**. **The** **bones** **of** **the** fins **of** **a** Devonian rhipidistian **exactly** **match** **in** **number** **and** **position** **the** limb **bones** **of** **the** earliest **known** tetrapods, **the** amphibians. **It** **should** **be** emphasized **that** **the** **evolution** **of** **lungs** **and** limbs **was** **in** **no** **sense** an anticipation **of** **future** **life** **on** **land**. **These** **adaptations** **developed** **because** **they** **helped** **fish** **to** **survive** **in** **their** **existing** aquatic **environment**.

**What** ecological **pressures** **might** **have** **caused** **fishes** **to** **gradually** **abandon** **their** watery habitat **and** **become** increasingly **land**-dwelling **creatures**? **Changes** **in** **climate** **during** **the** Devonian may **have** **had** **something** **to** **do** **with** **this** **if** freshwater **areas** **became** progressively **more** **restricted**. **Another** impetus may **have** **been** **new** sources **of** **food**. **The** **edges** **of** **ponds** **and** **streams** surely **had** scattered **dead** **fish** **and** **other** **water**-dwelling **creatures**. **In** **addition**, **plants** **had** emerged **into** terrestrial habitats **in** **areas** **near** **streams** **and** **ponds**, **and** crabs **and** **other** arthropods **were** **also** **members** **of** **this** earliest terrestrial community. **Thus**, **by** **the** Devonian **the** **land** habitat marginal **to** freshwater **was** **probably** **a** **rich** source **of** protein **that** **could** **be** **exploited** **by** an **animal** **that** **could** **easily** **climb** **out** **of** **water**. **Evidence** **from** **teeth** **suggests** **that** **these** earliest tetrapods **did** **not** utilize **land** **plants** **as** **food**; **they** **were** presumably carnivorous **and** **had** **not** **developed** **the** **ability** **to** **feed** **on** **plants**.

**How** **did** **the** **first** tetrapods **make** **the** transition **to** **a** terrestrial habitat? **Like** **early** **land** **plants** **such** **as** rhyniophytes, **they** **made** **only** **a** partial transition; **they** **were** **still** **quite** **tied** **to** **water**. **However**, **many** **problems** **that** **faced** **early** **land** **plants** **were** **not** applicable **to** **the** **first** tetrapods. **The** **ancestors** **of** **these** **animals** **already** **had** **a** circulation **system**, **and** **they** **were** **mobile**, **so** **that** **they** **could** **move** **to** **water** **to** **drink**. Furthermore, **they** **already** **had** **lungs**, **which** rhipidistians presumably **used** **for** auxiliary **breathing**. **The** principal **changes** **for** **the** earliest tetrapods **were** **in** **the** skeletal **system**—**changes** **in** **the** **bones** **of** **the** fins, **the** vertebral column, pelvic girdle, **and** pectoral girdle.

count: 202

# Official 36-Passage 03 Industrial Melanism: The Case of the Peppered Moth

**The** **idea** **of** **natural** selection **is** **that** organisms **in** **a** species **that** **have** **characteristics** favoring **survival** **are** **most** **likely** **to** **survive** **and** **produce** offspring **with** **the** **same** **characteristics**. **Because** **the** **survival** **of** organisms **with** **particular** **characteristics** **is** favored **over** **the** **survival** **of** **other** organisms **in** **the** **same** species **that** **lack** **these** **characteristics**, **future** **generations** **of** **the** species **are** **likely** **to** **include** **more** organisms **with** **the** favorable **characteristics**.

**One** **of** **the** **most** thoroughly **analyzed** **examples** **of** **natural** selection **in** **operation** **is** **the** **change** **in** color **that** **has** **occurred** **in** **certain** **populations** **of** **the** **peppered** moth, Biston betularia, **in** industrial regions **of** **Europe** **during** **the** **past** 100 **years**. Originally moths **were** uniformly **pale** gray **or** whitish **in** color; **dark**-colored (melanic) individuals **were** **rare** **and** **made** **up** **less** **than** 2 **percent** **of** **the** **population**. **Over** **a** **period** **of** **decades**, **dark**-colored **forms** **became** an increasingly **large** fraction **of** **some** **populations** **and** **eventually** **came** **to** dominate **peppered** moth **populations** **in** **certain** **areas**—**especially** **those** **of** **extreme** industrialization **such** **as** **the** Ruhr **Valley** **of** **Germany** **and** **the** Midlands **of** **England**. **Coal** **from** **industry** released **large** **amounts** **of** **black** soot **into** **the** **environment**, **but** **the** **increase** **of** **the** **dark**-colored **forms** **was** **not** **due** **to** genetic mutations **caused** **by** industrial **pollution**. **For** **example**, caterpillars **that** **feed** **on** soot-**covered** **leaves** **did** **not** **give** **rise** **to** **dark**-colored **adults**. **Rather**, **pollution** **promoted** **the** **survival** **of** **dark** **forms** **on** soot-**covered** **trees**. Melanics **were** normally quickly eliminated **in** nonindustrial **areas** **by** adverse selection; **birds** **spotted** **them** **easily**. **This** **phenomenon**, an **increase** **in** **the** frequency **of** **dark**-colored mutants **in** **polluted** **areas**, **is** **known** **as** industrial melanism. **The** **North** **American** equivalent **of** **this** **story** **is** **another** moth, **the** swettaria **form** **of** Biston cognataria, **first** **noticed** **in** industrialized **areas** **such** **as** Chicago **and** **New York** York **City** **in** **the** **early** 1900s. **By** 1961 **it** constituted **over** 90 **percent** **of** **the** **population** **in** **parts** **of** Michigan.

**The** **idea** **that** **natural** selection **was** responsible **for** **the** **changing** ratio **of** **dark**- **to** **light**-colored **peppered** moths **was** **developed** **in** **the** 1950s **by** H. B. D. Kettlewell **of** Oxford **University**. **If** **natural** selection **was** **the** **explanation**, **then** **there** **should** **be** **different** **survival** **rates** **for** **dark**- **and** **light**-colored moths. **To** **determine** **whether** **this** **was** **true**, Kettlewell released **thousands** **of** **light** **and** **dark** moths (**each** **marked** **with** **a** **paint** **spot**) **into** rural **and** industrialized **areas**. **In** **the** nonindustrial **area** **of** Dorset, **he** recaptured 14.6 **percent** **of** **the** **pale** **forms** **but** **only** 4.7 **percent** **of** **the** **dark** **forms**. **In** **the** industrial **area** **of** Birmingham, **the** **situation** **was** reversed: 13 **percent** **of** **pale** **forms** **but** 27.5 **percent** **of** **dark** **forms** **were** recaptured.

**Clearly** **some** environmental factor **was** responsible **for** **the** greater **survival** **rates** **of** **dark** moths. **Birds** **were** predators **of** **peppered** moths. Kettlewell hypothesized **that** **the** **normal** **pale** **forms** **are** **difficult** **to** **see** **when** **resting** **on** lichen-**covered** **trees**, whereas **dark** **forms** **are** conspicuous. **In** industrialized **areas**, lichens **are** **destroyed** **by** **pollution**, **tree** **barks** **become** darker, **and** **dark** moths **are** **the** **ones** **birds** **have** **difficulty** detecting. **As** **a** **test**, Kettlewell **set** **up** hidden observation **positions** **and** **watched** **birds** voraciously **eat** moths **placed** **on** **tree** **trunks** **of** **a** contrasting color. **The** **action** **of** **natural** selection **in** **producing** **a** **small** **but** highly significant **step** **of** **evolution** **was** seemingly demonstrated, **with** **birds** **as** **the** **selecting** **force**.

**Not** **every** researcher **has** **been** **convinced** **that** **natural** selection **by** **birds** **is** **the** **only** **explanation** **of** **the** **observed** frequencies **of** **dark** **and** **light** **peppered** moths. **More** **recent** **data**, **however**, **provide** additional **support** **for** Kettlewell’s **ideas** **about** **natural** selection. **The** **light**-colored **form** **of** **the** **peppered** moth **is** **making** **a** **strong** comeback. **In** **Britain**, **a** **Clean** **Air** **Act** **was** **passed** **in** 1965. **Sir** Cyril Clarke **has** **been** **trapping** moths **at** **his** **home** **in** Liverpool, Merseyside, **since** 1959. **Before** **about** 1975, 90 **percent** **of** **the** moths **were** **dark**, **but** **since** **then** **there** **has** **been** **a** **steep** **decline** **in** melanic **forms**, **and** **in** 1989 **only** 29.6 **percent** **of** **the** moths **caught** **were** melanic. **The** **mean** concentration **of** sulphur **dioxide** **pollution** **fell** **from** **about** 300 micrograms **per** **cubic** meter **in** 1970 **to** **less** **than** 50 micrograms **per** **cubic** meter **in** 1975 **and** **has** **remained** **fairly** **constant** **since** **then**. **If** **the** **spread** **of** **the** **light**-colored **form** **of** **the** moth **continues** **at** **the** **same** **speed** **as** **the** melanic **form** **spread** **in** **the** **last** **century**, **soon** **the** melanic **form** **will** **again** **be** **only** an occasional resident **of** **the** Liverpool **area**.

count: 202

# Official 05-Passage 02 The Origin of the Pacific Island People

**The** greater **Pacific** region, traditionally **called** **Oceania**, **consists** **of** **three** cultural **areas**: Melanesia, Micronesia, **and** Polynesia. Melanesia, **in** **the** **southwest** **Pacific**, **contains** **the** **large** **islands** **of** **New** Guinea, **the** Solomons, Vanuatu, **and** **New** Caledonia. Micronesia, **the** **area** **north** **of** Melanesia, **consists** primarily **of** **small** scattered **islands**. Polynesia **is** **the** **central** **Pacific** **area** **in** **the** **great** **triangle** defined **by** Hawaii, **Easter** **Island**, **and** **New Zealand** Zealand. **Before** **the** **arrival** **of** Europeans, **the** **islands** **in** **the** **two** largest cultural **areas**, Polynesia **and** Micronesia, **together** **contained** **a** **population** estimated **at** 700,000.

Speculation **on** **the** **origin** **of** **these** **Pacific** islanders **began** **as** **soon** **as** outsiders encountered **them**; **in** **the** **absence** **of** **solid** linguistic, archaeological, **and** biological **data**, **many** fanciful **and** mutually exclusive **theories** **were** devised. **Pacific** islanders **were** variously **thought** **to** **have** **come** **from** **North** **America**, **South** **America**, **Egypt**, Israel, **and** **India**, **as** **well** **as** **Southeast** **Asia**. **Many** older **theories** implicitly deprecated **the** navigational **abilities** **and** overall cultural creativity **of** **the** **Pacific** islanders. **For** **example**, **British** anthropologists G. Elliot Smith **and** W. J. Perry **assumed** **that** **only** **Egyptians** **would** **have** **been** **skilled** **enough** **to** navigate **and** colonize **the** **Pacific**. **They** inferred **that** **the** **Egyptians** **even** **crossed** **the** **Pacific** **to** **found** **the** **great** **civilizations** **of** **the** **New** **World** (**North** **and** **South** **America**). **In** 1947 Norwegian adventurer Thor Heyerdahl drifted **on** **a** balsa-log raft westward **with** **the** **winds** **and** currents **across** **the** **Pacific** **from** **South** **America** **to** **prove** **his** **theory** **that** **Pacific** islanders **were** **Native** Americans (**also** **called** **American** Indians). **Later** Heyerdahl **suggested** **that** **the** **Pacific** **was** **peopled** **by** **three** migrations: **by** **Native** Americans **from** **the** **Pacific** **Northwest** **of** **North** **America** drifting **to** Hawaii, **by** Peruvians drifting **to** **Easter** **Island**, **and** **by** Melanesians. **In** 1969 **he** **crossed** **the** **Atlantic** **in** an **Egyptian**-**style** reed **boat** **to** **prove** **Egyptian** **influences** **in** **the** Americas. **Contrary** **to** **these** theorists, **the** overwhelming **evidence** **of** **physical** anthropology, linguistics, **and** archaeology **shows** **that** **the** **Pacific** islanders **came** **from** **Southeast** **Asia** **and** **were** **skilled** **enough** **as** navigators **to** **sail** **against** **the** prevailing **winds** **and** currents.

**The** **basic** cultural **requirements** **for** **the** **successful** colonization **of** **the** **Pacific** **islands** **include** **the** **appropriate** **boat**-**building**, **sailing**, **and** navigation **skills** **to** **get** **to** **the** **islands** **in** **the** **first** **place**; domesticated **plants** **and** **gardening** **skills** **suited** **to** **often** marginal **conditions**; **and** **a** varied inventory **of** **fishing** implements **and** **techniques**. **It** **is** **now** generally **believed** **that** **these** prerequisites originated **with** **peoples** **speaking** Austronesian **languages** (**a** **group** **of** **several** **hundred** **related** **languages**) **and** **began** **to** emerge **in** **Southeast** **Asia** **by** **about** 5000 B.C.E. **The** **culture** **of** **that** **time**, **based** **on** archaeology **and** linguistic reconstruction, **is** **assumed** **to** **have** **had** **a** **broad** inventory **of** cultivated **plants** **including** taro, yams, **banana**, sugarcane, breadfruit, coconut, sago, **and** **rice**. **Just** **as** **important**, **the** **culture** **also** **possessed** **the** **basic** foundation **for** an effective maritime **adaptation**, **including** outrigger canoes **and** **a** **variety** **of** **fishing** **techniques** **that** **could** **be** effective **for** overseas **voyaging**.

**Contrary** **to** **the** **arguments** **of** **some** **that** **much** **of** **the** **Pacific** **was** **settled** **by** Polynesians accidentally marooned after **being** **lost** **and** adrift, **it** **seems** **reasonable** **that** **this** feat **was** **accomplished** **by** deliberate colonization expeditions **that** **set** **out** fully stocked **with** **food** **and** domesticated **plants** **and** **animals**. Detailed **studies** **of** **the** **winds** **and** currents **using** **computer** simulations **suggest** **that** drifting canoes **would** **have** **been** **a** **most** unlikely **means** **of** colonizing **the** **Pacific**. **These** expeditions **were** **likely** **driven** **by** **population** **growth** **and** **political** dynamics **on** **the** **home** **islands**, **as** **well** **as** **the** **challenge** **and** excitement **of** **exploring** **unknown** **waters**.

**Because** **all** Polynesians, Micronesians, **and** **many** Melanesians **speak** Austronesian **languages** **and** **grow** **crops** derived **from** **Southeast** **Asia**, **all** **these** **peoples** **most** **certainly** derived **from** **that** region **and** **not** **the** **New** **World** **or** elsewhere. **The** undisputed pre-Columbian presence **in** **Oceania** **of** **the** **sweet** **potato**, **which** **is** **a** **New** **World** domesticate, **has** **sometimes** **been** **used** **to** **support** Heyerdahl’s “**American** Indians **in** **the** **Pacific**” **theories**. **However**, **this** **is** **one** **plant** **out** **of** **a** **long** **list** **of** **Southeast** **Asian** domesticates. **As** Patrick Kirch, an **American** anthropologist, **points** **out**, **rather** **than** **being** **brought** **by** rafting **South** Americans, **sweet** **potatoes** **might** **just** **have** **easily** **been** **brought** **back** **by** **returning** Polynesian navigators **who** **could** **have** **reached** **the** **west** **coast** **of** **South** **America**.

count: 202

# Official 51-Passage 02 Surface Fluids on Venus and Earth

**A** fluid **is** **a** substance, **such** **as** **a** **liquid** **or** **gas**, **in** **which** **the** **component** particles (**usually** molecules) **can** **move** **past** **one** **another**. Fluids **flow** **easily** **and** conform **to** **the** **shape** **of** **their** **containers**. **The** geologic **processes** **related** **to** **the** **movement** **of** fluids **on** **a** **planet**’s **surface** **can** completely resurface **a** **planet** **many** **times**. **These** **processes** derive **their** energy **from** **the** **Sun** **and** **the** gravitational **forces** **of** **the** **planet** **itself**. **As** **these** fluids interact **with** **surface** **materials**, **they** **move** particles **about** **or** **react** chemically **with** **them** **to** modify **or** **produce** **materials**. **On** **a** **solid** **planet** **with** **a** hydrosphere **the** **combined** **mass** **of** **water** **on**, **under**, **or** **above** **a** **planet**’s **surface** **and** an **atmosphere**, **only** **a** **tiny** fraction **of** **the** planetary **mass** **flows** **as** **surface** fluids. **Yet** **the** **movements** **of** **these** fluids **can** drastically alter **a** **planet**. **Consider** Venus **and** **Earth**, **both** terrestrial **planets** **with** **atmospheres**.

Venus **and** **Earth** **are** commonly **regarded** **as** **twin** **planets** **but** **not** identical **twins**. **They** **are** **about** **the** **same** **size**, **are** composed **of** roughly **the** **same** **mix** **of** **materials**, **and** may **have** **been** comparably endowed **at** **their** **beginning** **with** **carbon** **dioxide** **and** **water**. **However**, **the** **twins** evolved differently, largely **because** **of** **differences** **in** **their** **distance** **from** **the** **Sun**. **With** **a** significant **amount** **of** internal **heat**, Venus may **continue** **to** **be** geologically **active** **with** **volcanoes**, rifting, **and** **folding**. **However**, **it** **lacks** **any** **sign** **of** **a** hydrologic **system** (**water** circulation **and** distribution): **there** **are** **no** **streams**, **lakes**, **oceans**, **or** glaciers. **Space** probes **suggest** **that** Venus may **have** **started** **with** **as** **much** **water** **as** **Earth**, **but** **it** **was** **unable** **to** **keep** **its** **water** **in** **liquid** **form**. **Because** Venus **receives** **more** **heat** **from** **the** **Sun**, **water** released **from** **the** interior evaporated **and** **rose** **to** **the** **upper** **atmosphere** **where** **the** **Sun**’s ultraviolet **rays** **broke** **the** molecules **apart**. **Much** **of** **the** **freed** **hydrogen** **escaped** **into** **space**, **and** Venus **lost** **its** **water**. **Without** **water**, Venus **became** **less** **and** **less** **like** **Earth** **and** **kept** an **atmosphere** **filled** **with** **carbon** **dioxide**. **The** **carbon** **dioxide** **acts** **as** **a** **blanket**, **creating** an intense greenhouse **effect** **and** **driving** **surface** **temperatures** **high** **enough** **to** melt **lead** **and** **to** **prohibit** **the** formation **of** carbonate **minerals**. **Volcanoes** continually vented **more** **carbon** **dioxide** **into** **the** **atmosphere**. **On** **Earth**, **liquid** **water** **removes** **carbon** **dioxide** **from** **the** **atmosphere** **and** **combines** **it** **with** calcium, **from** **rock** **weathering**, **to** **form** carbonate sedimentary **rocks**. **Without** **liquid** **water** **to** **remove** **carbon** **from** **the** **atmosphere**, **the** **level** **of** **carbon** **dioxide** **in** **the** **atmosphere** **of** Venus **remains** **high**.

**Like** Venus, **Earth** **is** **large** **enough** **to** **be** geologically **active** **and** **for** **its** gravitational **field** **to** **hold** an **atmosphere**. **Unlike** Venus, **it** **is** **just** **the** **right** **distance** **from** **the** **Sun** **so** **that** **temperature** **ranges** **allow** **water** **to** **exist** **as** **a** **liquid**, **a** **solid**, **and** **a** **gas**. **Water** **is** **thus** **extremely** **mobile** **and** **moves** rapidly **over** **the** **planet** **in** **a** continuous hydrologic **cycle**. **Heated** **by** **the** **Sun**, **the** **water** **moves** **in** **great** **cycles** **from** **the** **oceans** **to** **the** **atmosphere**, **over** **the** landscape **in** **river** **systems**, **and** ultimately **back** **to** **the** **oceans**. **As** **a** **result**, **Earth**’s **surface** **has** **been** continually **changed** **and** eroded **into** **delicate** **systems** **of** **river** **valleys**—**a** remarkable contrast **to** **the** **surfaces** **of** **other** planetary bodies **where** impact craters dominate. **Few** **areas** **on** **Earth** **have** **been** untouched **by** **flowing** **water**. **As** **a** **result**, **river** **valleys** **are** **the** dominant feature **of** **its** landscape. Similarly, **wind** **action** **has** scoured **fine** particles **away** **from** **large** **areas**, **depositing** **them** elsewhere **as** **vast** **sand** **seas** dominated **by** dunes **or** **in** **sheets** **of** loess (**fine**-**grained** **soil** **deposits**). **These** fluid **movements** **are** **caused** **by** **gravity** **flow** **systems** energized **by** **heat** **from** **the** **Sun**. **Other** geologic **changes** **occur** **when** **the** **gases** **in** **the** **atmosphere** **or** **water** **react** **with** **rocks** **at** **the** **surface** **to** **form** **new** **chemical** compounds **with** **different** properties. An **important** **example** **of** **this** **process** **was** **the** removal **of** **most** **of** **Earth**’s **carbon** **dioxide** **from** **its** **atmosphere** **to** **form** carbonate **rocks**. **However**, **if** **Earth** **were** **a** **little** closer **to** **the** **Sun**, **its** **oceans** **would** evaporate; **if** **it** **were** farther **from** **the** **Sun**, **the** **oceans** **would** **freeze** **solid**. **Because** **liquid** **water** **was** **present**, **self**-replicating molecules **of** **carbon**, **hydrogen**, **and** **oxygen** **developed** **life** **early** **in** **Earth**’s **history** **and** **have** radically modified **its** **surface**, **blanketing** **huge** **parts** **of** **the** **continents** **with** greenery. **Life** thrives **on** **this** **planet**, **and** **it** **helped** **create** **the** **planet**’s **oxygen** **and** nitrogen-**rich** **atmosphere** **and** moderate **temperatures**.

count: 202

# Official 12-Passage 03 Water in the Desert

**Rainfall** **is** **not** completely **absent** **in** **desert** **areas**, **but** **it** **is** highly variable. An **annual** **rainfall** **of** **four** **inches** **is** **often** **used** **to** define **the** **limits** **of** **a** **desert**. **The** impact **of** **rainfall** **upon** **the** **surface** **water** **and** groundwater resources **of** **the** **desert** **is** greatly **influenced** **by** landforms. **Flats** **and** depressions **where** **water** **can** **collect** **are** **common** features, **but** **they** **make** **up** **only** **a** **small** **part** **of** **the** landscape.

Arid **lands**, surprisingly, **contain** **some** **of** **the** **world**’s largest **river** **systems**, **such** **as** **the** Murray-Darling **in** **Australia**, **the** Rio Grande **in** **North** **America**, **the** Indus **in** **Asia**, **and** **the** Nile **in** **Africa**. **These** **rivers** **and** **river** **systems** **are** **known** **as** “exogenous” **because** **their** sources **lie** **outside** **the** arid **zone**. **They** **are** **vital** **for** sustaining **life** **in** **some** **of** **the** driest **parts** **of** **the** **world**. **For** **centuries**, **the** **annual** **floods** **of** **the** Nile, Tigris, **and** Euphrates, **for** **example**, **have** **brought** fertile silts **and** **water** **to** **the** inhabitants **of** **their** lower **valleys**. **Today**, **river** discharges **are** increasingly **controlled** **by** **human** intervention, **creating** **a** **need** **for** **international** **river**-**basin** **agreements**. **The** **filling** **of** **the** Ataturk **and** **other** **dams** **in** **Turkey** **has** drastically **reduced** **flows** **in** **the** Euphrates, **with** potentially **serious** **consequences** **for** Syria **and** Iraq.

**The** **flow** **of** exogenous **rivers** varies **with** **the** **season**. **The** **desert** **sections** **of** **long** **rivers** **respond** **several** **months** after **rain** **has** **fallen** **outside** **the** **desert**, **so** **that** peak **flows** may **be** **in** **the** **dry** **season**. **This** **is** **useful** **for** **irrigation**, **but** **the** **high** **temperatures**, **low** humidities, **and** **different** **day** **lengths** **of** **the** **dry** **season**, **compared** **to** **the** **normal** **growing** **season**, **can** **present** **difficulties** **with** **some** **crops**.

Regularly **flowing** **rivers** **and** **streams** **that** originate **within** arid **lands** **are** **known** **as** “endogenous”. **These** **are** generally **fed** **by** groundwater **springs**, **and** **many** issue **from** limestone massifs, **such** **as** **the** Atlas **Mountains** **in** Morocco. Basaltic **rocks** **also** **support** **springs**, notably **at** **the** Jabal Al-**Arab** **on** **the** Jordan-Syria **border**. Endogenous **rivers** **often** **do** **not** **reach** **the** **sea** **but** drain **into** **inland** **basins**, **where** **the** **water** evaporates **or** **is** **lost** **in** **the** **ground**. **Most** **desert** streambeds **are** normally **dry**, **but** **they** occasionally **receive** **large** **flows** **of** **water** **and** sediment.

**Deserts** **contain** **large** **amounts** **of** groundwater **when** **compared** **to** **the** **amounts** **they** **hold** **in** **surface** **stores** **such** **as** **lakes** **and** **rivers**. **But** **only** **a** **small** fraction **of** groundwater **enters** **the** hydrological **cycle**--**feeding** **the** **flows** **of** **streams**, maintaining **lake** **levels**, **and** **being** recharged (**or** refilled) **through** **surface** **flows** **and** rainwater. **In** **recent** **years**, groundwater **has** **become** an increasingly **important** source **of** freshwater **for** **desert** dwellers. **The** **United** **Nations** **Environment** **Programme** **and** **the** **World** **Bank** **have** funded **attempts** **to** survey **the** groundwater resources **of** arid **lands** **and** **to** **develop** **appropriate** extraction **techniques**. **Such** programs **are** **much** **needed** **because** **in** **many** arid **lands** **there** **is** **only** **a** **vague** **idea** **of** **the** extent **of** groundwater resources. **It** **is** **known**, **however**, **that** **the** distribution **of** groundwater **is** uneven, **and** **that** **much** **of** **it** **lies** **at** **great** **depths**.

Groundwater **is** **stored** **in** **the** pore **spaces** **and** joints **of** **rocks** **and** unconsolidated (unsolidified) sediments **or** **in** **the** **openings** widened **through** fractures **and** **weathering**. **The** **water**-saturated **rock** **or** sediment **is** **known** **as** an “aquifer”. **Because** **they** **are** porous, sedimentary **rocks**, **such** **as** sandstones **and** conglomerates, **are** **important** **potential** sources **of** groundwater. **Large** **quantities** **of** **water** may **also** **be** **stored** **in** limestones **when** joints **and** cracks **have** **been** **enlarged** **to** **form** cavities. **Most** limestone **and** sandstone aquifers **are** **deep** **and** extensive **but** may **contain** groundwaters **that** **are** **not** **being** recharged. **Most** **shallow** aquifers **in** **sand** **and** gravel **deposits** **produce** lower yields, **but** **they** **can** **be** rapidly recharged. **Some** **deep** aquifers **are** **known** **as** “fossil” **waters**. **The** **term** “fossil” **describes** **water** **that** **has** **been** **present** **for** **several** **thousand** **years**. **These** aquifers **became** saturated **more** **than** 10,000 **years** **ago** **and** **are** longer **being** recharged.

**Water** **does** **not** **remain** immobile **in** an aquifer **but** **can** seep **out** **at** **springs** **or** **leak** **into** **other** aquifers. **The** **rate** **of** **movement** may **be** **very** **slow**: **in** **the** Indus **plain**, **the** **movement** **of** saline (**salty**) groundwaters **has** **still** **not** **reached** equilibrium after 70 **years** **of** **being** **tapped**. **The** **mineral** **content** **of** groundwater normally **increases** **with** **the** **depth**, **but** **even** **quite** **shallow** aquifers **can** **be** highly saline.

count: 201

# Official 17-Passage 02 Animal Signals in the Rain Forest

**The** daytime **quality** **of** **light** **in** **forests** varies **with** **the** density **of** **the** vegetation, **the** **angle** **of** **the** **Sun**, **and** **the** **amount** **of** **cloud** **in** **the** **sky**. **Both** **animals** **and** **plants** **have** **different** **appearances** **in** **these** **various** **lighting** **conditions**. **A** color **or** **pattern** **that** **is** relatively indistinct **in** **one** **kind** **of** **light** may **be** **quite** conspicuous **in** **another**.

**In** **the** varied **and** constantly **changing** **light** **environment** **of** **the** **forest**, an **animal** must **be** **able** **to** **send** **visual** **signals** **to** **members** **of** **its** **own** species **and** **at** **the** **same** **time** **avoid** **being** detected **by** predators. An **animal** **can** **hide** **from** predators **by** **choosing** **the** **light** **environment** **in** **which** **its** **pattern** **is** **least** visible. **This** may **require** **moving** **to** **different** **parts** **of** **the** **forest** **at** **different** **times** **of** **the** **day** **or** **under** **different** **weather** **conditions**, **or** **it** may **be** **achieved** **by** **changing** color **according to** **the** **changing** **light** **conditions**. **Many** species **of** amphibians (**frogs** **and** toads) **and** reptiles (lizards **and** **snakes**) **are** **able** **to** **change** **their** color **patterns** **to** camouflage **themselves**. **Some** **also** **signal** **by** **changing** color. **The** chameleon lizard **has** **the** **most** **striking** **ability** **to** **do** **this**. **Some** chameleon species **can** **change** **from** **a** **rather** **dull** **appearance** **to** **a** **full** riot **of** carnival colors **in** **seconds**. **By** **this** **means**, **they** **signal** **their** **level** **of** **aggression** **or** readiness **to** mate.

**Other** species **take** **into** **account** **the** **changing** **conditions** **of** **light** **by** **performing** **their** **visual** displays **only** **when** **the** **light** **is** favorable. **A** **male** **bird** **of** paradise may **put** **himself** **in** **the** limelight **by** displaying **his** spectacular plumage **in** **the** **best** **stage** **setting** **to** **attract** **a** **female**. **Certain** **butterflies** **move** **into** **spots** **of** **sunlight** **that** **have** penetrated **to** **the** **forest** **floor** **and** display **by** **opening** **and** **closing** **their** beautifully **patterned** **wings** **in** **the** **bright** spotlights. **They** **also** **compete** **with** **each** **other** **for** **the** **best** **spot** **of** **sunlight**.

**Very** **little** **light** filters **through** **the** canopy **of** **leaves** **and** **branches** **in** **a** **rain** **forest** **to** **reach** **ground** **level**—**or** **close** **to** **the** **ground**—**and** **at** **those** **levels** **the** **yellow**-**to**-**green** wavelengths predominate. **A** **signal** **might** **be** **most** **easily** **seen** **if** **it** **is** maximally **bright**. **In** **the** **green**-**to**-**yellow** **lighting** **conditions** **of** **the** lowest **levels** **of** **the** **forest**, **yellow** **and** **green** **would** **be** **the** brightest colors, **but** **when** an **animal** **is** **signaling**, **these** colors **would** **not** **be** **very** visible **if** **the** **animal** **was** **sitting** **in** an **area** **with** **a** yellowish **or** greenish **background**. **The** **best** **signal** **depends** **not** **only** **on** **its** brightness **but** **also** **on** **how** **well** **it** contrasts **with** **the** **background** **against** **which** **it** must **be** **seen**. **In** **this** **part** **of** **the** **rain** **forest**, **therefore**, **red** **and** **orange** **are** **the** **best** colors **for** **signaling**, **and** **they** **are** **the** colors **used** **in** **signals** **by** **the** **ground**-**walking** **Australian** **brush** **turkey**. **This** species, **which** **lives** **in** **the** **rain** **forests** **and** scrublands **of** **the** **east** **coast** **of** **Australia**, **has** **a** **brown**-**to**-**black** plumage **with** **bare**, **bright**-**red** **skin** **on** **the** **head** **and** **neck** **and** **a** **neck** **collar** **of** **orange**-**yellow** loosely **hanging** **skin**. **During** courtship **and** **aggressive** displays, **the** **turkey** **enlarges** **its** colored **neck** **collar** **by** inflating sacs **in** **the** **neck** region **and** **then** flings **about** **a** pendulous **part** **of** **the** colored **signaling** apparatus **as** **it** utters **calls** **designed** **to** **attract** **or** repel. **This** impressive display **is** **clearly** visible **in** **the** **light** spectrum illuminating **the** **forest** **floor**.

**Less** colorful **birds** **and** **animals** **that** inhabit **the** **rain** **forest** **tend** **to** **rely** **on** **forms** **of** **signaling** **other** **than** **the** **visual**, particularly **over** **long** **distances**. **The** piercing **cries** **of** **the** rhinoceros hornbill characterize **the** **Southeast** **Asian** **rain** **forest**, **as** **do** **the** unmistakable **calls** **of** **the** gibbons. **In** densely **wooded** **environments**, **sound** **is** **the** **best** **means** **of** **communication** **over** **distance** **because** **in** comparison **with** **light**, **it** **travels** **with** **little** impediment **from** **trees** **and** **other** vegetation. **In** **forests**, **visual** **signals** **can** **be** **seen** **only** **at** **short** **distances**, **where** **they** **are** **not** obstructed **by** **trees**. **The** **male** riflebird **exploits** **both** **of** **these** modes **of** **signaling** simultaneously **in** **his** courtship display. **The** **sounds** **made** **as** **each** **wing** **is** **opened** **carry** **extremely** **well** **over** **distance** **and** **advertise** **his** presence widely. **The** ritualized **visual** display **communicates** **in** **close** **quarters** **when** **a** **female** **has** **approached**.

count: 201

# Official 28-Passage 03 Buck Rubs and Buck Scrapes

**A** conspicuous **sign** indicating **the** presence **of** **white**-**tailed** **deer** **in** **a** woodlot **is** **a** buck rub. **A** **male** **deer** **makes** **a** buck rub **by** stripping **the** **bark** (**outer** layer) **of** **a** **small** **tree** **with** **its** antlers. **When** **completed**, **the** buck rub **is** an **obvious** **visual** **signal** **to** us **and** presumably **to** **other** **deer** **in** **the** **area**. **A** rub **is** **usually** located **at** **the** **shoulder** **height** **of** **a** **deer** (**one** meter **or** **less** **above** **the** **ground**) **on** **a** **smooth**-**barked**, **small**-diameter (16–25 millimeters) **tree**. **The** **smooth** **bark** **of** **small** **red** **maples** **makes** **this** species ideal **for** buck rubs **in** **the** **forests** **of** **the** mid-**eastern** **United** **States**.

**Adult** **male** **deer** **usually** **produce** rubs **in** **late** **summer** **or** **early** **autumn** **when** **the** **outer** velvet layer **is** **being** shed **from** **their** antlers. Rubs **are** **created** **about** **one** **to** **two** **months** **before** **the** breeding **season** (**the** rut). Hence **for** **a** **long** **time** biologists **believed** **that** **male** **deer** **used** buck rubs **not** **only** **to** **clean** **and** **polish** antlers **but** **also** **to** **provide** **practice** **for** **the** ensuing **male**-**to**-**male** combat **during** **the** rut. **However**, biologists **also** **noted** **that** **deer** **sniff** **and** lick an unfamiliar rub, **which** **suggests** **that** **this** **visual** **mark** **on** **a** **small** **tree** **plays** an **important** **communication** **purpose** **in** **the** **social** **life** **of** **deer**.

Buck rubs **also** **have** **a** scent **produced** **by** glands **in** **the** **foreheads** **of** **deer** **that** **is** transferred **to** **the** **tree** **when** **the** rub **is** **made**. **These** odors **make** buck rubs an **important** **means** **of** olfactory **communication** **between** **deer**. **The** **importance** **of** olfactory **communication** (**using** odors **to** **communicate**) **in** **the** **way** **of** **life** **of** **deer** **was** **documented** **by** **a** **study** **of** captive **adult** mule **deer** **a** **few** **decades** **ago**, **which** **noted** **that** **males** rubbed **their** **foreheads** **on** **branches** **and** twigs, **especially** **as** **autumn** **approached**. **A** **decade** **later** **another** **study** **reported** **that** **adult** **male** **white**-**tailed** **deer** exhibited **forehead** rubbing **just** **before** **and** **during** **the** rut. **It** **was** **found** **that** **when** **a** **white**-**tailed** buck **makes** **a** rub, **it** **moves** **both** antlers **and** **forehead** glands **along** **the** **small** **tree** **in** **a** **vertical** **direction**. **This** **forehead** rubbing behavior coincides **with** **a** **high** **level** **of** glandular **activity** **in** **the** modified scent glands **found** **on** **the** **foreheads** **of** **male** **deer**; **the** glandular **activity** **causes** **the** **forehead** pelage (hairy **covering**) **of** **adult** **males** **to** **be** distinctly darker **than** **in** **females** **or** younger **males**.

**Forehead** rubbing **by** **male** **deer** **on** buck rubs presumably **sends** **a** **great** **deal** **of** **information** **to** **other** **members** **of** **the** **same** species. **First**, **the** **chemicals** **deposited** **on** **the** rub **provide** **information** **on** **the** individual **identity** **of** an **animal**; **no** **two** mammals **produce** **the** **same** scent. **For** instance, **as** **we** **all** **know**, **dogs** recognize **each** **other** **via** **smell**. **Second**, **because** **only** **male** **deer** rub, **the** buck rub **and** **its** **associated** **chemicals** indicate **the** **sex** **of** **the** **deer** **producing** **the** rub. **Third**, older, **more** dominant bucks **produce** **more** buck rubs **and** **probably** **deposit** **more** glandular secretions **on** **a** **given** rub. **Thus**, **the** presence **of** **many** **well**-**marked** rubs **is** indicative **of** older, higher-**status** **males** **being** **in** **the** **general** vicinity **rather** **than** **simply** **being** **a** crude **measure** **of** **relative** **deer** abundance **in** **a** **given** **area**. **The** **information** **conveyed** **by** **the** olfactory **signals** **on** **a** buck rub **make** **it** **the** **social** equivalent **of** **some** auditory **signals** **in** **other** **deer** species, **such** **as** trumpeting **by** bull elk.

**Because** **both** **sexes** **of** whitetails **respond** **to** buck rubs **by** **smelling** **and** licking **them**, rubs may **serve** **a** **very** **important** additional **function**. Fresher buck rubs (**less** **than** **two** **days** **old**), **in** **particular**, **are** **visited** **more** frequently **by** **adult** **females** **than** older rubs. **In** **view** **of** **this** behavior **it** **has** **been** **suggested** **that** **chemicals** **present** **in** **fresh** buck rubs may **help** physiologically induce **and** synchronize fertility **in** **females** **that** **visit** **these** rubs. **This** **would** **be** an **obvious** **advantage** **to** **wide**-**ranging** **deer**, **especially** **to** **a** **when** **courting** **several** **adult** **females** **during** **the** **autumn** rut. **Another** **visual** **signal** **produced** **by** **white**-**tailed** **deer** **is** **termed** **a** buck scrape. Scrapes **consist** **of** **a** **clearing** (**about** 0.5 meter **in** diameter) **and** **shallow** depression **made** **by** **pushing** **aside** **the** **leaves** **covering** **the** **ground**; after **making** **the** scrape, **the** **deer** typically urinates **in** **the** depression. **Thus**, **like** **a** buck rub, **a** scrape **is** **both** **a** **visual** **and** an olfactory **signal**. Buck scrapes **are** generally **created** after **leaf**-**fall** **in** **autumn**, **which** **is** **just** **before** **or** **during** **the** rut. Scrapes **are** **usually** **placed** **in** **open** **or** conspicuous **places**, **such** **as** **along** **a** **deer** trail. **Most** **are** **made** **by** older **males**, **although** **females** **and** younger **males** (2.5 **years** **old** **or** **less**) occasionally **make** scrapes.

count: 201

# Official 39-Passage 02 The Extinction of Moa

**Between** 80 **and** 85 **million** **years** **ago**, Gondwanaland, **a** giant **continent** **made** **up** **of** **what** **today** **is** **Africa**, **Antarctica**, **Australia**, **and** **South** **America**, **broke** **up**, **thus** **causing** **what** **is** **now** **New Zealand** Zealand **to** **become** **separated** **from** **the** larger landmass. After **the** **separation**, **any** **creature** **unable** **to** **cross** **a** considerable **distance** **of** **ocean** **could** **not** migrate **to** **New Zealand** Zealand. **Snakes** **and** **most** mammals evolved after **the** **separation**. **Thus** **there** **are** **no** **New Zealand** Zealand **snakes**, **and** **bats**, **which** **flew** **there**, **and** **seals**, **which** **swam** **there**, **were** **the** **only** mammals **on** **New Zealand** Zealand **when** Polynesian **settlers** (**the** Maori) **arrived** **there** **about** **a** **thousand** **years** **ago**.

**When** **the** Maori **arrived** **in** **New Zealand** Zealand, **they** encountered **birds** **that** **had** **been** evolving **for** 80 **million** **years** **without** **the** presence **of** mammalian predators. **The** **most** **striking** **of** **these** **animals** must **have** **been** **moa**. **Now** extinct, **moa** **were** gigantic wingless **birds** **that** **stood** **as** **much** **as** 10 **feet** (3 meters) **tall** **and** **weighed** **as** **much** **as** 550 **pounds** (250 **kilograms**). **They** **are** **known** **from** **a** **diverse** array **of** **remains** **including** eggshells, **eggs**, **a** **few** mummified carcasses, **vast** **numbers** **of** **bones**, **and** **some** older fossilized **bone**. **The** species **of** **moa** **that** **are** currently recognized occupied ecological niches customarily **filled** elsewhere **by** **large** mammalian browsing herbivores. **They** may **have** **had** relatively **low** reproductive **rates**; apparently, **they** **usually** **laid** **only** **one** **egg** **at** **a** **time**.

**It** **seems** **possible** **that** **when** **Captain** James **Cook** **first** **visited** **New Zealand** Zealand **in** 1769, **moa** (**or** **at** **least** **one** **of** **the** **moa** species) may **have** **still** **survived** **in** **the** **remote** **areas** **in** **the** **western** **part** **of** **New Zealand** Zealand’s **South** **Island**. **If** **so**, **these** individuals **would** **have** **been** **the** **last** **of** **their** **kind**. Climatic **conditions** **in** **New Zealand** Zealand **appear** **to** **have** **been** relatively **stable** **over** **the** **period** **during** **which** **moa** **became** extinct. **Different** factors **could** **have** worked **in** **concert** **to** **account** **for** **their** **abrupt** disappearance.

Vegetation **was** considerably altered **by** **the** Maori **occupation** **of** **New Zealand** Zealand, **a** **change** **not** **easily** **explained** **by** **climate** variation **or** **other** **possible** factors. **Forest** **and** shrubland **burning** **appears** **to** **have** **reduced** **the** prime habitat **of** **many** **moa** species. **However**, **the** **main** **forest** **burning** **started** **around** 700 **years** **ago**, after **what** current archaeological **evidence** indicates **was** **the** **most** intensive **stage** **of** **moa** **hunting**. **While** **there** **appears** **to** **have** **been** extensive **burning** **on** **the** **east** **side** **of** **New Zealand** Zealand’s **South** **Island**, **large** **forest** tracts **remained** **in** **the** **most** **southern** **part** **of** **the** **island**. **Because** **major** habitat destruction **seems** **to** **have** **occurred** after **moa** **populations** **already** **were** depleted, **and** **because** **some** habitat **that** **could** **have** **sheltered** **moa** **populations** **remained**, **it** **would** **seem** **that** **other** factors **were** **also** **at** **work** **in** **the** extinction **of** **these** **birds**.

**For** **South** **Island**, **human** predation **appears** **to** **have** **been** **a** significant factor **in** **the** depletion **of** **the** **population** **of** **moa**. **At** **one** excavated Maori site, **moa** **remains** **filled** **six** **railway** **cars**. **The** density **of** Maori **settlements** **and** artifacts **increased** substantially **at** **the** **time** **of** **the** **most** intensive **moa** **hunting** (900 **to** 600 **years** **ago**). **This** **period** **was** **followed** **by** **a** **time** **of** **decline** **in** **the** Maori **population** **and** **a** societal transition **to** smaller, **less** numerous **settlements**. **The** **apparent** **decline** **fits** **the** **pattern** **expected** **as** **a** **consequence** **of** **the** Maori’s overexploitation **of** **moa**.

Finally, **the** Maori **introduced** **the** Polynesian **rat** **and** **the** **dog** **to** **New Zealand** Zealand. **The** **actions** **of** **these** **potential** **nest** predators **could** **have** **reduced** **moa** **populations** **without** **leaving** **much** **direct** **evidence**. **The** Maori may **have** **also** inadvertently **brought** **pests** **and** **disease** organisms **in** fowls, **which** **could** **have** **crossed** **over** **to** eradicate **moa** **populations**. **The** **possibility** **of** **analyzing** **ancient** DNA **to** identify **past** **diseases** **of** extinct **animals** **is** **being** **explored**. **However**, **evidence** **of** **such** **diseases** **is** **difficult** **to** **determine** directly **from** paleoecological **or** archaeological **remains**. **For** **these** **reasons**, **it** **is** **hard** **to** **determine** **the** likelihood **that** **introduced** **disease** organisms **were** **a** **cause** **of** **the** **decline** **of** **moa**, **but** **they** **are** potentially significant.

**While** **the** **last** **of** **these** **possible** **causes** **remains** speculative, definite clues **exist** **for** **the** **action** **of** **the** **first** **two** **causes**. **The** **story** **of** **moa** species **and** **their** demise **raises** ecological issues **on** **the** vulnerability **of** species **to** **human**-**caused** **changes**—**including** altered vegetative **cover** **of** **the** landscape, **change** **in** **the** **physical** **environment**, **and** modification **of** **the** flora **and** fauna **of** **a** region **by** eliminating **some** species **and** **introducing** **others**.

count: 201

# Official 15-Passage 01 A Warm-Blooded Turtle

**When** **it** **comes** **to** physiology, **the** leatherback turtle **is**, **in** **some** **ways**, **more** **like** **a** reptilian **whale** **than** **a** turtle. **It** **swims** farther **into** **the** **cold** **of** **the** **northern** **and** **southern** **oceans** **than** **any** **other** **sea** turtle, **and** **it** **deals** **with** **the** chilly **waters** **in** **a** **way** **unique** **among** reptiles.

**A** **warm**-**blooded** turtle may **seem** **to** **be** **a** contradiction **in** **terms**. Nonetheless, an **adult** leatherback **can** maintain **a** body **temperature** **of** **between** 25 **and** 26°C (77–79°**F**) **in** seawater **that** **is** **only** 8°C (46.4°**F**). **Accomplishing** **this** feat **requires** **adaptations** **both** **to** generate **heat** **in** **the** turtle’s body **and** **to** **keep** **it** **from** **escaping** **into** **the** **surrounding** **waters**. Leatherbacks apparently **do** **not** generate internal **heat** **the** **way** **we** **do**, **or** **the** **way** **birds** **do**, **as** **a** **by**-**product** **of** cellular metabolism. **A** leatherback may **be** **able** **to** **pick** **up** **some** body **heat** **by** basking **at** **the** **surface**; **its** **dark**, **almost** **black** body color may **help** **it** **to** **absorb** **solar** **radiation**. **However**, **most** **of** **its** internal **heat** **comes** **from** **the** **action** **of** **its** muscles.

Leatherbacks **keep** **their** body **heat** **in** **three** **different** **ways**. **The** **first**, **and** simplest, **is** **size**. **The** bigger **the** **animal** **is**, **the** lower **its** **surface**-**to**-volume ratio; **for** **every** ounce **of** body **mass**, **there** **is** proportionately **less** **surface** **through** **which** **heat** **can** **escape**. An **adult** leatherback **is** **twice** **the** **size** **of** **the** biggest cheloniid **sea** turtles **and** **will** **therefore** **take** longer **to** **cool** **off**. Maintaining **a** **high** body **temperature** **through** sheer bulk **is** **called** gigantothermy. **It** **works** **for** **elephants**, **for** **whales**, **and**, **perhaps**, **it** worked **for** **many** **of** **the** larger **dinosaurs**. **It** apparently **works**, **in** **a** smaller **way**, **for** **some** **other** **sea** turtles. **Large** loggerhead **and** **green** turtles **can** maintain **their** body **temperature** **at** **a** **degree** **or** **two** **above** **that** **of** **the** **surrounding** **water**, **and** gigantothermy **is** **probably** **the** **way** **they** **do** **it**. Muscular **activity** **helps**, **too**, **and** an actively **swimming** **green** turtle may **be** 7°C (12.6°**F**) warmer **than** **the** **waters** **it** **swims** **through**.

Gigantothermy, **though**, **would** **not** **be** **enough** **to** **keep** **a** leatherback **warm** **in** **cold** **northern** **waters**. **It** **is** **not** **enough** **for** **whales**, **which** supplement **it** **with** **a** **thick** layer **of** insulating blubber (**fat**). Leatherbacks **do** **not** **have** blubber, **but** **they** **do** **have** **a** reptilian equivalent: **thick**, **oil**-saturated **skin**, **with** **a** layer **of** fibrous, fatty **tissue** **just** **beneath** **it**. Insulation **protects** **the** leatherback **everywhere** **but** **on** **its** **head** **and** flippers. **Because** **the** flippers **are** comparatively **thin** **and** blade **like**, **they** **are** **the** **one** **part** **of** **the** leatherback **that** **is** **likely** **to** **become** chilled. **There** **is** **not** **much** **that** **the** turtle **can** **do** **about** **this** **without** **compromising** **the** aerodynamic **shape** **of** **the** flipper. **The** **problem** **is** **that** **as** **blood** **flows** **through** **the** turtle’s flippers, **it** **risks** **losing** **enough** **heat** **to** lower **the** **animal**’s **central** body **temperature** **when** **it** **returns**. **The** solution **is** **to** **allow** **the** flippers **to** **cool** **down** **without** **drawing** **heat** **away** **from** **the** **rest** **of** **the** turtle’s body. **The** leatherback **accomplishes** **this** **by** **arranging** **the** **blood** vessels **in** **the** **base** **of** **its** flipper **into** **a** countercurrent **exchange** **system**.

**In** **a** countercurrent **exchange** **system**, **the** **blood** vessels **carrying** **cooled** **blood** **from** **the** flippers **run** **close** **enough** **to** **the** **blood** vessels **carrying** **warm** **blood** **from** **the** body **to** **pick** **up** **some** **heat** **from** **the** warmer **blood** vessels; **thus**, **the** **heat** **is** transferred **from** **the** **outgoing** **to** **the** ingoing vessels **before** **it** **reaches** **the** flipper **itself**. **This** **is** **the** **same** **arrangement** **found** **in** an **old**-fashioned **steam** radiator, **in** **which** **the** coiled **pipes** **pass** **heat** **back** **and** forth **as** **water** **courses** **through** **them**. **The** leatherback **is** **certainly** **not** **the** **only** **animal** **with** **such** an **arrangement**; gulls **have** **a** countercurrent **exchange** **in** **their** **legs**. **That** **is** **why** **a** gull **can** **stand** **on** an **ice** floe **without** **freezing**.

**All** **this** **applies**, **of** **course**, **only** **to** an **adult** leatherback. Hatchlings **are** **simply** **too** **small** **to** conserve body **heat**, **even** **with** insulation **and** countercurrent **exchange** **systems**. **We** **do** **not** **know** **how** **old**, **or** **how** **large**, **a** leatherback **has** **to** **be** **before** **it** **can** **switch** **from** **a** **cold-blooded** **to** **a** **warm**-**blooded** mode **of** **life**. Leatherbacks **reach** **their** immense **size** **in** **a** **much** shorter **time** **than** **it** **takes** **other** **sea** turtles **to** **grow**. **Perhaps** **their** **rush** **to** adulthood **is** **driven** **by** **a** **simple** **need** **to** **keep** **warm**.

count: 200

# Official 42-Passage 03 Callisto and Ganymede

**From** 1996 **to** 1999, **the** Galileo spacecraft **passed** **through** **the** Jovian **system**, **providing** **much** **information** **about** Jupiter’s **satellites**. Callisto, **the** outermost **of** Jupiter’s **four** largest **satellites**, **orbits** **the** **planet** **in** **seventeen** **days** **at** **a** **distance** **from** Jupiter **of** **two** **million** kilometers. **Like** **our** **own** **Moon**, Callisto rotates **in** **the** **same** **period** **as** **it** revolves, **so** **it** **always** **keeps** **the** **same** **face** **toward** Jupiter. **Its** noontime **surface** **temperature** **is** **only** **about** −140ºC, **so** **water** **ice** **is** **stable** **on** **its** **surface** **year**-**round**. Callisto **has** **a** diameter **of** 4,820 kilometers, **almost** **the** **same** **as** **that** **of** Mercury. **Its** **mass** **is** **only** **one**-**third** **as** **great**, **which** **means** **its** density must **be** **only** **one**-**third** **as** **great** **as** **well**. **This** **tells** us **that** Callisto **has** **far** **less** **of** **the** rocky metallic **materials** **found** **in** **the** inner **planets** **and** must **instead** **be** an icy body **through** **much** **of** **its** interior.

Callisto **has** **not** fully differentiated, **meaning** **separated** **into** layers **of** **different** density **materials**. **Astronomers** **can** **tell** **that** **it** **lacks** **a** dense core **from** **the** details **of** **its** gravitational **pull** **on** **the** Galileo spacecraft **during** **several** **very** **close** flybys. **This** **fact** **surprised** **scientists**, **who** **expected** **that** **all** **the** **big** icy **moons** **would** **be** differentiated. **It** **is** **much** easier **for** an icy body **to** differentiate **than** **for** **a** rocky **one**, **since** **the** melting **temperature** **of** **ice** **is** **so** **low**. **Only** **a** **little** **heating** **will** soften **the** **ice** **and** **get** **the** **process** **started**, **allowing** **the** **rock** **and** **metal** **to** **sink** **to** **the** center **and** **the** slushy **ice** **to** **float** **to** **the** **surface**. **Yet** Callisto **seems** **to** **have** **frozen** **solid** **before** **the** **process** **of** differentiation **was** **complete**.

**Like** **our** **Moon**’s highlands, **the** **surface** **of** Callisto **is** **covered** **with** impact craters. **The** **survival** **of** **these** craters **tells** us **that** an icy **object** **can** **form** **and** retain impact craters **in** **its** **surface**. **In** **thinking** **of** **ice** **so** **far** **from** **the** **Sun**, **it** **is** **important** **not** **to** **judge** **its** behavior **from** **that** **of** **the** **much** warmer **ice** **we** **know** **on** **Earth**; **at** **the** **temperatures** **of** **the** **outer** **solar** **system**, **ice** **on** **the** **surface** **is** **nearly** **as** **hard** **as** **rock**, **and** **behaves** similarly. **Ice** **on** Callisto **does** **not** deform **or** **flow** **like** **ice** **in** glaciers **on** **Earth**. Callisto **is** **unique** **among** **the** **planet**-**sized** **objects** **of** **the** **solar** **system** **in** **its** **absence** **of** interior **forces** **to** **drive** geological **evolution**. **The** **satellite** **was** **born** **dead** **and** **has** **remained** geologically **dead** **for** **more** **than** **four** **billion** **years**.

Ganymede, **another** **of** Jupiter’s **satellites** **and** **the** largest **in** **our** **solar** **system**, **is** **also** cratered, **but** **less** **so** **than** Callisto. **About** **one**-**quarter** **of** **its** **surface** **seems** **to** **be** **as** **old** **and** **heavily** cratered; **the** **rest** **formed** **more** recently, **as** **we** **can** **tell** **by** **the** sparse **covering** **of** impact craters **as** **well** **as** **the** **relative** freshness **of** **the** craters. Ganymede **is** **a** differentiated **world**, **like** **the** terrestrial **planets**. Measurements **of** **its** **gravity** **field** **tell** us **that** **the** **rock** **and** **metal** **sank** **to** **form** **a** core **about** **the** **size** **of** **our** **Moon**, **with** **a** mantle **and** crust **of** **ice** **floating** **above** **it**. **In** **addition**, **the** Galileo spacecraft **discovered** **that** Ganymede **has** **a** magnetic **field**, **the** **signature** **of** **a** partially molten interior. Ganymede **is** **not** **a** **dead** **world**, **but** **rather** **a** **place** **of** **continuing** geological **activity** **powered** **by** an internal **heat** source. **Much** **of** **its** **surface** may **be** **as** **young** **as** **half** **a** **billion** **years**.

**The** younger terrain **is** **the** **result** **of** tectonic **and** volcanic **forces**. **Some** features **formed** **when** **the** crust cracked, **flooding** **many** **of** **the** craters **with** **water** **from** **the** interior. Extensive **mountain** **ranges** **were** **formed** **from** compression **of** **the** crust, **forming** **long** ridges **with** **parallel** **valleys** **spaced** **one** **to** **two** kilometers **apart**. **In** **some** **places** older impact craters **were** **split** **and** **pulled** **apart**. **There** **are** **even** indications **of** **large**-scale crustal **movements** **that** **are** **similar** **to** **the** **plate** tectonics **of** **Earth**.

**Why** **is** Ganymede **different** **from** Callisto? **Possibly** **the** **small** **difference** **in** **size** **and** internal **heating** **between** **the** **two** **led** **to** **this** divergence **in** **their** **evolution**. **But** **more** **likely** **the** **gravity** **of** Jupiter **is** **to** **blame** **for** Ganymede’s **continuing** geological **activity**. Ganymede **is** **close** **enough** **to** Jupiter **that** tidal **forces** **from** **the** giant **planet** may **have** episodically **heated** **its** interior **and** triggered **major** convulsions **on** **its** crust.

count: 199

# Official 13-Passage 02 Biological Clocks

**Survival** **and** **successful** reproduction **usually** **require** **the** **activities** **of** **animals** **to** **be** coordinated **with** predictable **events** **around** **them**. Consequently, **the** **timing** **and** rhythms **of** biological **functions** must closely **match** periodic **events** **like** **the** **solar** **day**, **the** tides, **the** lunar **cycle**, **and** **the** **seasons**. **The** **relations** **between** **animal** **activity** **and** **these** **periods**, particularly **for** **the** **daily** rhythms, **have** **been** **of** **such** **interest** **and** **importance** **that** **a** **huge** **amount** **of** **work** **has** **been** **done** **on** **them** **and** **the** **special** **research** **field** **of** chronobiology **has** emerged. Normally, **the** constantly **changing** **levels** **of** an **animal**’s **activity**—**sleeping**, **feeding**, **moving**, reproducing, metabolizing, **and** **producing** enzymes **and** hormones, **for** **example**—**are** **well** coordinated **with** environmental rhythms, **but** **the** **key** **question** **is** **whether** **the** **animal**’s **schedule** **is** **driven** **by** external cues, **such** **as** **sunrise** **or** **sunset**, **or** **is** **instead** dependent somehow **on** internal timers **that** **themselves** generate **the** **observed** biological rhythms. **Almost** universally, biologists **accept** **the** **idea** **that** **all** eukaryotes (**a** **category** **that** **includes** **most** organisms **except** **bacteria** **and** **certain** algae) **have** internal **clocks**. **By** isolating organisms completely **from** external periodic cues, biologists **learned** **that** organisms **have** internal **clocks**. **For** instance, apparently **normal** **daily** **periods** **of** biological **activity** **were** maintained **for** **about** **a** **week** **by** **the** fungus Neurospora **when** **it** **was** intentionally isolated **from** **all** geophysical **timing** cues **while** **orbiting** **in** **a** **space** **shuttle**. **The** continuation **of** biological rhythms **in** an organism **without** external cues attests **to** **its** **having** an internal **clock**.

**When** crayfish **are** **kept** continuously **in** **the** **dark**, **even** **for** **four** **to** **five** **months**, **their** compound **eyes** **continue** **to** **adjust** **on** **a** **daily** **schedule** **for** daytime **and** nighttime vision. Horseshoe crabs **kept** **in** **the** **dark** continuously **for** **a** **year** **were** **found** **to** maintain **a** persistent rhythm **of** **brain** **activity** **that** similarly **adapts** **their** **eyes** **on** **a** **daily** **schedule** **for** **bright** **or** **for** **weak** **light**. **Like** **almost** **all** **daily** **cycles** **of** **animals** deprived **of** environmental cues, **those** **measured** **for** **the** horseshoe crabs **in** **these** **conditions** **were** **not** **exactly** 24 **hours**. **Such** **a** rhythm **whose** **period** **is** **approximately**—**but** **not** **exactly**—**a** **day** **is** **called** circadian. **For** **different** individual horseshoe crabs, **the** circadian **period** **ranged** **from** 22.2 **to** 25.5 **hours**. **A** **particular** **animal** typically maintains **its** **own** **characteristic** **cycle** duration **with** **great** precision **for** **many** **days**. **Indeed**, stability **of** **the** biological **clock**’s **period** **is** **one** **of** **its** **major** features, **even** **when** **the** organism’s **environment** **is** **subjected** **to** considerable **changes** **in** factors, **such** **as** **temperature**, **that** **would** **be** **expected** **to** **affect** biological **activity** strongly. Further **evidence** **for** persistent internal rhythms **appears** **when** **the** **usual** external **cycles** **are** shifted—**either** experimentally **or** **by** **rapid** **east**-**west** **travel** **over** **great** **distances**. Typically, **the** **animal**’s **daily** internally generated **cycle** **of** **activity** **continues** **without** **change**. **As** **a** **result**, **its** **activities** **are** shifted **relative** **to** **the** external **cycle** **of** **the** **new** **environment**. **The** disorienting **effects** **of** **this** mismatch **between** external **time** cues **and** internal **schedules** may persist, **like** **our** **jet** lag, **for** **several** **days** **or** **weeks** **until** **certain** cues **such** **as** **the** **daylight**/**darkness** **cycle** reset **the** organism’s **clock** **to** synchronize **with** **the** **daily** rhythm **of** **the** **new** **environment**.

**Animals** **need** **natural** periodic **signals** **like** **sunrise** **to** maintain **a** **cycle** **whose** **period** **is** precisely 24 **hours**. **Such** an external cue **not** **only** coordinates an **animal**’s **daily** rhythms **with** **particular** features **of** **the** **local** **solar** **day** **but** **also**—**because** **it** normally **does** **so** **day** after **day**—**seems** **to** **keep** **the** internal **clock**’s **period** **close** **to** **that** **of** **Earth**’s rotation. **Yet** despite **this** synchronization **of** **the** **period** **of** **the** internal **cycle**, **the** **animal**’s timer **itself** **continues** **to** **have** **its** **own** genetically **built**-**in** **period** **close** **to**, **but** **different** **from**, 24 **hours**. **Without** **the** external cue, **the** **difference** **accumulates** **and** **so** **the** internally regulated **activities** **of** **the** biological **day** drift continuously, **like** **the** tides, **in** **relation** **to** **the** **solar** **day**. **This** drift **has** **been** **studied** extensively **in** **many** **animals** **and** **in** biological **activities** **ranging** **from** **the** **hatching** **of** **fruit** **fly** **eggs** **to** **wheel** **running** **by** **squirrels**. **Light** **has** **a** predominating **influence** **in** **setting** **the** **clock**. **Even** **a** **fifteen**-**minute** **burst** **of** **light** **in** **otherwise** sustained **darkness** **can** reset an **animal**’s circadian rhythm. Normally, internal rhythms **are** **kept** **in** **step** **by** **regular** environmental **cycles**. **For** instance, **if** **a** **homing** pigeon **is** **to** navigate **with** **its** **Sun** **compass**, **its** **clock** must **be** **properly** **set** **by** cues **provided** **by** **the** **daylight**/**darkness** **cycle**.

count: 198

# Official 27-Passage 03 Predator-Prey Cycles

**How** **do** predators **affect** **populations** **of** **the** prey **animals**? **The** **answer** **is** **not** **as** **simple** **as** **might** **be** **thought**. Moose **reached** Isle Royale **in** **Lake** **Superior** **by** **crossing** **over** **winter** **ice** **and** **multiplied** freely **there** **in** isolation **without** predators. **When** **wolves** **later** **reached** **the** **island**, naturalists widely **assumed** **that** **the** **wolves** **would** **play** **a** **key** **role** **in** **controlling** **the** moose **population**. **Careful** **studies** **have** demonstrated, **however**, **that** **this** **is** **not** **the** **case**. **The** **wolves** **eat** mostly **old** **or** **diseased** **animals** **that** **would** **not** **survive** **long** anyway. **In** **general**, **the** moose **population** **is** **controlled** **by** **food** availability, **disease**, **and** **other** factors **rather** **than** **by** **the** **wolves**.

**When** experimental **populations** **are** **set** **up** **under** **simple** laboratory **conditions**, **the** predator **often** exterminates **its** prey **and** **then** **becomes** extinct **itself**, **having** **nothing** **left** **to** **eat**. **However**, **if** **safe** **areas** **like** **those** prey **animals** **have** **in** **the** **wild** **are** **provided**, **the** prey **population** **drops** **to** **low** **levels** **but** **not** **to** extinction. **Low** prey **population** **levels** **then** **provide** inadequate **food** **for** **the** predators, **causing** **the** predator **population** **to** **decrease**. **When** **this** **occurs**, **the** prey **population** **can** rebound. **In** **this** **situation** **the** predator **and** prey **populations** may **continue** **in** **this** cyclical **pattern** **for** **some** **time**.

**Population** **cycles** **are** **characteristic** **of** **some** species **of** **small** mammals, **and** **they** **sometimes** **appear** **to** **be** **brought** **about** **by** predators. Ecologists **studying** hare **populations** **have** **found** **that** **the** **North** **American** snowshoe hare **follows** **a** roughly **ten**-**year** **cycle**. **Its** **numbers** **fall** tenfold **to** thirtyfold **in** **a** **typical** **cycle**, **and** **a** hundredfold **change** **can** **occur**. **Two** factors **appear** **to** **be** generating **the** **cycle**: **food** **plants** **and** predators.

**The** **preferred** **foods** **of** snowshoe hares **are** willow **and** birch twigs. **As** hare density **increases**, **the** **quantity** **of** **these** twigs **decreases**, **forcing** **the** hares **to** **feed** **on** **low**-**quality**, **high**-fiber **food**. Lower **birth** **rates**, **low** juvenile survivorship, **and** **low** **growth** **rates** **follow**, **so** **there** **is** **a** **corresponding** **decline** **in** hare abundance. **Once** **the** hare **population** **has** **declined**, **it** **takes** **two** **to** **three** **years** **for** **the** **quantity** **of** twigs **to** **recover**.

**A** **key** predator **of** **the** snowshoe hare **is** **the** **Canada** lynx. **The** **Canada** lynx **shows** **a** **ten**-**year** **cycle** **of** abundance **that** **parallels** **the** abundance **cycle** **of** hares. **As** hare **numbers** **increase**, lynx **numbers** **do** **too**, **rising** **in** response **to** **the** **increased** availability **of** lynx **food**. **When** hare **numbers** **fall**, **so** **do** lynx **numbers**, **as** **their** **food** **supply** **is** depleted.

**What** **causes** **the** predator-prey oscillations? **Do** **increasing** **numbers** **of** hares **lead** **to** overharvesting **of** **plants**, **which** **in** **turn** **results** **in** **reduced** hare **populations**, **or** **do** **increasing** **numbers** **of** lynx **lead** **to** overharvesting **of** hares? **Field** **experiments** **carried** **out** **by** Charles Krebs **and** coworkers **in** 1992 **provide** an **answer**. Krebs investigated experimental **plots** **in** **Canada**’s Yukon territory **that** **contained** hare **populations**. **When** **food** **was** **added** **to** **these** **plots** (**no** **food** **effect**) **and** predators **were** excluded (**no** predator **effect**) **from** an experimental **area**, hare **numbers** **increased** tenfold **and** **stayed** **there**—**the** **cycle** **was** **lost**. **However**, **the** **cycle** **was** retained **if** **either** **of** **the** factors **was** **allowed** **to** **operate** **alone**: **if** predators **were** excluded **but** **food** **was** **not** **added** (**food** **effect** **alone**), **or** **if** **food** **was** **added** **in** **the** presence **of** predators (predator **effect** **alone**). **Thus**, **both** factors **can** **affect** **the** **cycle**, **which**, **in** **practice**, **seems** **to** **be** generated **by** **the** conjunction **of** **the** **two** factors.

Predators **are** an essential factor **in** maintaining communities **that** **are** **rich** **and** **diverse** **in** species. **Without** predators, **the** species **that** **is** **the** **best** **competitor** **for** **food**, **shelter**, **nesting** sites, **and** **other** environmental resources **tends** **to** dominate **and** exclude **the** species **with** **which** **it** **competes**. **This** **phenomenon** **is** **known** **as** “**competitor** exclusion.” **However**, **if** **the** community **contains** **a** predator **of** **the** strongest **competitor** species, **then** **the** **population** **of** **that** **competitor** **is** **controlled**. **Thus** **even** **the** **less** competitive species **are** **able** **to** **survive**. **For** **example**, **sea** **stars** prey **on** **a** **variety** **of** bivalve mollusks **and** **prevent** **these** bivalves **from** monopolizing habitats **on** **the** **sea** **floor**. **This** **opens** **up** **space** **for** **many** **other** organisms. **When** **sea** **stars** **are** **removed**, species diversity **falls** sharply. **Therefore**, **from** **the** standpoint **of** diversity, **it** **is** **usually** **a** **mistake** **to** eliminate **a** **major** predator **from** **a** community.

count: 197

# Official 05-Passage 01 Minerals and Plants

**Research** **has** **shown** **that** **certain** **minerals** **are** **required** **by** **plants** **for** **normal** **growth** **and** **development**. **The** **soil** **is** **the** source **of** **these** **minerals**, **which** **are** **absorbed** **by** **the** **plant** **with** **the** **water** **from** **the** **soil**. **Even** nitrogen, **which** **is** **a** **gas** **in** **its** elemental **state**, **is** normally **absorbed** **from** **the** **soil** **as** nitrate ions. **Some** **soils** **are** notoriously deficient **in** micro nutrients **and** **are** **therefore** **unable** **to** **support** **most** **plant** **life**. **So**-**called** serpentine **soils**, **for** **example**, **are** deficient **in** calcium, **and** **only** **plants** **able** **to** **tolerate** **low** **levels** **of** **this** **mineral** **can** **survive**. **In** **modern** **agriculture**, **mineral** depletion **of** **soils** **is** **a** **major** **concern**, **since** **harvesting** **crops** **interrupts** **the** **recycling** **of** nutrients **back** **to** **the** **soil**.

**Mineral** deficiencies **can** **often** **be** detected **by** **specific** **symptoms** **such** **as** chlorosis (**loss** **of** chlorophyll **resulting** **in** **yellow** **or** **white** **leaf** **tissue**), necrosis (isolated **dead** patches), anthocyanin formation (**development** **of** **deep** **red** pigmentation **of** **leaves** **or** stem), stunted **growth**, **and** **development** **of** woody **tissue** **in** an herbaceous **plant**. **Soils** **are** **most** commonly deficient **in** nitrogen **and** phosphorus. Nitrogen-deficient **plants** exhibit **many** **of** **the** **symptoms** **just** **described**. **Leaves** **develop** chlorosis; stems **are** **short** **and** slender; **and** anthocyanin discoloration **occurs** **on** stems, petioles, **and** lower **leaf** **surfaces**. Phosphorus-deficient **plants** **are** **often** stunted, **with** **leaves** **turning** **a** **characteristic** **dark** **green**, **often** **with** **the** accumulation **of** anthocyanin. Typically, older **leaves** **are** **affected** **first** **as** **the** phosphorus **is** mobilized **to** **young** **growing** **tissue**. **Iron** deficiency **is** characterized **by** chlorosis **between** veins **in** **young** **leaves**.

**Much** **of** **the** **research** **on** nutrient deficiencies **is** **based** **on** **growing** **plants** hydroponically, **that** **is**, **in** soilless **liquid** nutrient solutions. **This** **technique** **allows** researchers **to** **create** solutions **that** selectively omit **certain** nutrients **and** **then** **observe** **the** **resulting** **effects** **on** **the** **plants**. Hydroponics **has** **applications** **beyond** **basic** **research**, **since** **it** facilitates **the** **growing** **of** greenhouse **vegetables** **during** **winter**. Aeroponics, **a** **technique** **in** **which** **plants** **are** suspended **and** **the** **roots** **misted** **with** **a** nutrient solution, **is** **another** **method** **for** **growing** **plants** **without** **soil**.

**While** **mineral** deficiencies **can** **limit** **the** **growth** **of** **plants**, an overabundance **of** **certain** **minerals** **can** **be** toxic **and** **can** **also** **limit** **growth**. Saline **soils**, **which** **have** **high** concentrations **of** sodium chloride **and** **other** **salts**, **limit** **plant** **growth**, **and** **research** **continues** **to** **focus** **on** **developing** **salt**-tolerant **varieties** **of** **agricultural** **crops**. **Research** **has** **focused** **on** **the** toxic **effects** **of** **heavy** **metals** **such** **as** **lead**, cadmium, mercury, **and** aluminum; **however**, **even** copper **and** zinc, **which** **are** essential elements, **can** **become** toxic **in** **high** concentrations. **Although** **most** **plants** cannot **survive** **in** **these** **soils**, **certain** **plants** **have** **the** **ability** **to** **tolerate** **high** **levels** **of** **these** **minerals**.

**Scientists** **have** **known** **for** **some** **time** **that** **certain** **plants**, **called** hyperaccumulators, **can** **concentrate** **minerals** **at** **levels** **a** hundredfold **or** greater **than** **normal**. **A** survey **of** **known** hyperaccumulators identified **that** 75 **percent** **of** **them** amassed nickel; cobalt, copper, zinc, manganese, **lead**, **and** cadmium **are** **other** **minerals** **of** **choice**. Hyperaccumulators **run** **the** **entire** **range** **of** **the** **plant** **world**. **They** may **be** **herbs**, shrubs, **or** **trees**. **Many** **members** **of** **the** **mustard** **family**, spurge **family**, legume **family**, **and** **grass** **family** **are** **top** hyperaccumulators. **Many** **are** **found** **in** tropical **and** subtropical **areas** **of** **the** **world**, **where** accumulation **of** **high** concentrations **of** **metals** may **afford** **some** **protection** **against** **plant**-**eating** **insects** microbial pathogens.

**Only** recently **have** investigators **considered** **using** **these** **plants** **to** **clean** **up** **soil** **and** **waste** sites **that** **have** **been** contaminated **by** toxic **levels** **of** **heavy** **metals**—an environmentally **friendly** **approach** **known** **as** phytoremediation. **This** scenario **begins** **with** **the** **planting** **of** hyperaccumulating species **in** **the** **target** **area**, **such** **as** an **abandoned** **mine** **or** an **irrigation** **pond** contaminated **by** runoff. Toxic **minerals** **would** **first** **be** **absorbed** **by** **roots** **but** **later** relocated **to** **the** stem **and** **leaves**. **A** **harvest** **of** **the** **shoots** **would** **remove** **the** toxic compounds **off** site **to** **be** **burned** **or** composted **to** **recover** **the** **metal** **for** industrial **uses**. After **several** **years** **of** cultivation **and** **harvest**, **the** site **would** **be** restored **at** **a** **cost** **much** lower **than** **the** **price** **of** excavation **and** reburial, **the** **standard** **practice** **for** remediation **of** contaminated **soils**. **For** **example**, **in** **field** **trials**, **the** **plant** alpine pennycress **removed** zinc **and** cadmium **from** **soils** **near** **a** zinc smelter, **and** **Indian** **mustard**, **native** **to** Pakistan **and** **India**, **has** **been** effective **in** **reducing** **levels** **of** selenium **salts** **by** 50 **percent** **in** contaminated **soils**.

count: 197

# Official 15-Passage 03 Glacier Formation

Glaciers **are** slowly **moving** **masses** **of** **ice** **that** **have** **accumulated** **on** **land** **in** **areas** **where** **more** **snow** **falls** **during** **a** **year** **than** melts. **Snow** **falls** **as** hexagonal crystals, **but** **once** **on** **the** **ground**, **snow** **is** **soon** **transformed** **into** **a** compacted **mass** **of** smaller, **rounded** **grains**. **As** **the** **air** **space** **around** **them** **is** lessened **by** compaction **and** melting, **the** **grains** **become** denser. **With** further melting, refreezing, **and** **increased** **weight** **from** newer snowfall **above**, **the** **snow** **reaches** **a** granular recrystallized **stage** intermediate **between** flakes **and** **ice** **known** **as** firn. **With** additional **time**, **pressure**, **and** refrozen meltwater **from** **above**, **the** **small** firn granules **become** larger, interlocked crystals **of** **blue** glacial **ice**. **When** **the** **ice** **is** **thick** **enough**, **usually** **over** 30 meters, **the** **weight** **of** **the** **snow** **and** firn **will** **cause** **the** **ice** crystals **toward** **the** **bottom** **to** **become** **plastic** **and** **to** **flow** **outward** **or** **downward** **from** **the** **area** **of** **snow** accumulation.

Glaciers **are** **open** **systems**, **with** **snow** **as** **the** **system**’s input **and** meltwater **as** **the** **system**’s **main** **output**. **The** glacial **system** **is** **governed** **by** **two** **basic** climatic variables: precipitation **and** **temperature**. **For** **a** glacier **to** **grow** **or** maintain **its** **mass**, **there** must **be** sufficient snowfall **to** **match** **or** exceed **the** **annual** **loss** **through** melting, evaporation, **and** calving, **which** **occurs** **when** **the** glacier **loses** **solid** chunks **as** icebergs **to** **the** **sea** **or** **to** **large** **lakes**. **If** **summer** **temperatures** **are** **high** **for** **too** **long**, **then** **all** **the** snowfall **from** **the** previous **winter** **will** melt. **Surplus** snowfall **is** essential **for** **a** glacier **to** **develop**. **A** **surplus** **allows** **snow** **to** **accumulate** **and** **for** **the** **pressure** **of** **snow** **accumulated** **over** **the** **years** **to** **transform** **buried** **snow** **into** glacial **ice** **with** **a** **depth** **great** **enough** **for** **the** **ice** **to** **flow**. Glaciers **are** **sometimes** **classified** **by** **temperature** **as** faster-**flowing** temperate glaciers **or** **as** slower-**flowing** polar glaciers.

Glaciers **are** **part** **of** **Earth**’s hydrologic **cycle** **and** **are** **second** **only** **to** **the** **oceans** **in** **the** **total** **amount** **of** **water** **contained**. **About** 2 **percent** **of** **Earth**’s **water** **is** currently **frozen** **as** **ice**. **Two** **percent** may **be** **a** deceiving **figure**, **however**, **since** **over** 80 **percent** **of** **the** **world**’s **fresh** **water** **is** **locked** **up** **as** **ice** **in** glaciers, **with** **the** **majority** **of** **it** **in** **Antarctica**. **The** **total** **amount** **of** **ice** **is** **even** **more** **awesome** **if** **we** estimate **the** **water** released **upon** **the** hypothetical melting **of** **the** **world**’s glaciers. **Sea** **level** **would** **rise** **about** 60 meters. **This** **would** **change** **the** **geography** **of** **the** **planet** considerably. **In** contrast, **should** **another** **ice** **age** **occur**, **sea** **level** **would** **drop** drastically. **During** **the** **last** **ice** **age**, **sea** **level** **dropped** **about** 120 meters.

**When** **snow** **falls** **on** **high** **mountains** **or** **in** polar regions, **it** may **become** **part** **of** **the** glacial **system**. **Unlike** **rain**, **which** **returns** rapidly **to** **the** **sea** **or** **atmosphere**, **the** **snow** **that** **becomes** **part** **of** **a** glacier **is** involved **in** **a** **much** **more** slowly **cycling** **system**. **Here** **water** may **be** **stored** **in** **ice** **form** **for** **hundreds** **or** **even** **hundreds** **of** **thousands** **of** **years** **before** **being** released **again** **into** **the** **liquid** **water** **system** **as** meltwater. **In** **the** meantime, **however**, **this** **ice** **is** **not** static. Glaciers **move** slowly **across** **the** **land** **with** tremendous energy, **carving** **into** **even** **the** hardest **rock** formations **and** thereby reshaping **the** landscape **as** **they** engulf, **push**, **drag**, **and** finally **deposit** **rock** debris **in** **places** **far** **from** **its** original location. **As** **a** **result**, glaciers **create** **a** **great** **variety** **of** landforms **that** **remain** **long** after **the** **surface** **is** released **from** **its** icy **covering**.

**Throughout** **most** **of** **Earth**’s **history**, glaciers **did** **not** **exist**, **but** **at** **the** **present** **time** **about** 10 **percent** **of** **Earth**’s **land** **surface** **is** **covered** **by** glaciers. **Present**-**day** glaciers **are** **found** **in** **Antarctica**, **in** Greenland, **and** **at** **high** elevations **on** **all** **the** **continents** **except** **Australia**. **In** **the** **recent** **past**, **from** **about** 2.4 **million** **to** **about** 10,000 **years** **ago**, **nearly** **a** **third** **of** **Earth**’s **land** **area** **was** periodically **covered** **by** **ice** **thousands** **of** meters **thick**. **In** **the** **much** **more** **distant** **past**, **other** **ice** **ages** **have** **occurred**.

count: 197

# Official 47-Passage 03 Coral Reefs

    An **important** **environment** **that** **is** **more** **or** **less** **totally** **restricted** **to** **the** intertropical **zone** **is** **the** **coral** reef. **Coral** reefs **are** **found** **where** **the** **ocean** **water** **temperature** **is** **not** **less** **than** 21°C, **where** **there** **is** **a** **firm** substratum, **and** **where** **the** seawater **is** **not** rendered **too** **dark** **by** excessive **amounts** **of** **river**-borne sediment. **They** **will** **not** **grow** **in** **very** **deep** **water**, **so** **a** **platform** **within** 30 **to** 40 meters **of** **the** **surface** **is** **a** **necessary** prerequisite **for** **their** **development**. **Their** **physical** structure **is** dominated **by** **the** skeletons **of** **corals**, **which** **are** carnivorous **animals** **living** **off** zooplankton. **However**, **in** **addition** **to** **corals** **there** **are** enormous **quantities** **of** algae, **some** calcareous, **which** **help** **to** **build** **the** reefs. **The** **size** **of** reefs **is** variable. **Some** atolls **are** **very** **large**—Kwajelein **in** **the** Marshall **Islands** **of** **the** **South** **Pacific** **is** 120 kilometers **long** **and** **as** **much** **as** 24 kilometers **across**—**but** **most** **are** **very** **much** smaller, **and** **rise** **only** **a** **few** meters **above** **the** **water**. **The** 2,000 kilometer **complex** **of** reefs **known** **as** **the** **Great** **Barrier** Reef, **which** **forms** **a** gigantic **natural** breakwater **off** **the** **northeast** **coast** **of** **Australia**, **is** **by** **far** **the** greatest **coral** structure **on** **Earth**.

**Coral** reefs **have** fascinated **scientists** **for** **almost** 200 **years**, **and** **some** **of** **the** **most** pertinent observations **of** **them** **were** **made** **in** **the** 1830s **by** Charles Darwin **on** **the** **voyage** **of** **the** Beagle. **He** recognized **that** **there** **were** **three** **major** **kinds**: fringing reefs, **barrier** reefs, **and** atolls; **and** **he** **saw** **that** **they** **were** **related** **to** **each** **other** **in** **a** logical **and** gradational sequence. **A** fringing reef **is** **one** **that** **lies** **close** **to** **the** **shore** **of** **some** **continent** **or** **island**. **Its** **surface** **forms** an uneven **and** **rather** **rough** **platform** **around** **the** **coast**, **about** **the** **level** **of** **low** **water**, **and** **its** **outer** **edge** slopes **downwards** **into** **the** **sea**. **Between** **the** fringing reef **and** **the** **land** **there** **is** **sometimes** **a** **small** **channel** **or** lagoon. **When** **the** lagoon **is** **wide** **and** **deep** **and** **the** reef **lies** **at** **some** **distance** **from** **the** **shore** **and** **rises** **from** **deep** **water** **it** **is** **called** **a** **barrier** reef. An atoll **is** **a** reef **in** **the** **form** **of** **a** **ring** **or** horseshoe **with** **a** lagoon **in** **the** center.

    Darwin’s **theory** **was** **that** **the** succession **from** **one** **coral** reef **type** **to** **another** **could** **be** **achieved** **by** **the** **upward** **growth** **of** **coral** **from** **a** **sinking** **platform**, **and** **that** **there** **would** **be** **a** progression **from** **a** fringing reef, **through** **the** **barrier** reef **stage** **until**, **with** **the** disappearance **through** subsidence (**sinking**) **of** **the** **central** **island**, **only** **a** reef-enclosed lagoon **or** atoll **would** **survive**. **A** **long** **time** after Darwin **put** **forward** **this** **theory**, **some** **deep** boreholes **were** **drilled** **in** **the** **Pacific** atolls **in** **the** 1950s. **The** **drill** **holes** **passed** **through** **more** **than** **a** **thousand** meters **of** **coral** **before** **reaching** **the** **rock** substratum **of** **the** **ocean** **floor**, **and** indicated **that** **the** **coral** **had** **been** **growing** **upward** **for** **tens** **of** **millions** **of** **years** **as** **Earth**’s crust subsided **at** **a** **rate** **of** **between** 15 **and** 51 meters **per** **million** **years**. Darwin’s **theory** **was** **therefore** **proved** basically **correct**. **There** **are** **some** submarine **islands** **called** guyots **and** seamounts, **in** **which** subsidence **associated** **with** **sea**-**floor** **spreading** **has** **been** **too** speedy **for** **coral** **growth** **to** **keep** **up**.

**Like** mangrove swamps, **coral** reefs **are** **extremely** **important** habitats. **Their** diversity **of** **coral** genera **is** greatest **in** **the** **warm** **waters** **of** **the** **Indian** **Ocean** **and** **the** **western** **Pacific**. **Indeed**, **they** **have** **been** **called** **the** marine **version** **of** **the** tropical **rain** **forest**, rivaling **their** terrestrial counterparts **in** **both** richness **of** species **and** biological productivity. **They** **also** **have** **significance** **because** **they** **provide** coastal **protection**, opportunities **for** **recreation**, **and** **are** **potential** sources **of** substances **like** medicinal **drugs**. **At** **present** **they** **are** **coming** **under** **a** **variety** **of** threats, **of** **which** **two** **of** **the** **most** **important** **are** dredging **and** **the** **effects** **of** **increased** siltation **brought** **about** **by** **accelerated** erosion **from** neighboring **land** **areas**.

count: 196

# Official 21-Passage 03 Autobiographical Memory

**Think** **back** **to** **your** **childhood** **and** **try** **to** identify **your** earliest **memory**. **How** **old** **were** **you**? **Most** **people** **are** **not** **able** **to** recount **memories** **for** **experiences** prior **to** **the** **age** **of** **three** **years**, **a** **phenomenon** **called** infantile amnesia. **The** **question** **of** **why** infantile amnesia **occurs** **has** intrigued psychologists **for** **decades**, **especially** **in** **light** **of** **ample** **evidence** **that** infants **and** **young** **children** **can** display impressive **memory** capabilities. **Many** **find** **that** **understanding** **the** **general** **nature** **of** autobiographical **memory**, **that** **is**, **memory** **for** **events** **that** **have** **occurred** **in** **one**’s **own** **life**, **can** **provide** **some** **important** clues **to** **this** mystery. **Between** **ages** **three** **and** **four**, **children** **begin** **to** **give** **fairly** lengthy **and** cohesive **descriptions** **of** **events** **in** **their** **past**. **What** factors **are** responsible **for** **this** developmental **turning** **point**?

**Perhaps** **the** **explanation** **goes** **back** **to** **some** **ideas** **raised** **by** influential **Swiss** psychologist Jean Piaget—namely, **that** **children** **under** **age** **two** **years** **represent** **events** **in** **a** qualitatively **different** **form** **than** older **children** **do**. **According to** **this** **line** **of** **thought**, **the** verbal **abilities** **that** blossom **in** **the** **two** **year** **old** **allow** **events** **to** **be** coded **in** **a** **form** radically **different** **from** **the** **action**-**based** codes **of** **the** infant. Verbal **abilities** **of** **one** **year** **olds** **are**, **in** **fact**, **related** **to** **their** **memories** **for** **events** **one** **year** **later**. **When** researchers **had** **one** **year** **olds** imitate an **action** sequence **one** **year** after **they** **first** **saw** **it**, **there** **was** correlation **between** **the** **children**’s verbal **skills** **at** **the** **time** **they** **first** **saw** **the** **event** **and** **their** **success** **on** **the** **later** **memory** **task**. **However**, **even** **children** **with** **low** verbal **skills** **showed** **evidence** **of** **remembering** **the** **event**; **thus**, **memories** may **be** facilitated **by** **but** **are** **not** dependent **on** **those** verbal **skills**.

**Another** **suggestion** **is** **that** **before** **children** **can** **talk** **about** **past** **events** **in** **their** **lives**, **they** **need** **to** **have** **a** **reasonable** **understanding** **of** **the** **self** **as** **a** psychological entity. **The** **development** **of** an **understanding** **of** **the** **self** **becomes** **evident** **between** **the** **first** **and** **second** **years** **of** **life** **and** **shows** **rapid** elaboration **in** subsequent **years**. **The** realization **that** **the** **physical** **self** **has** continuity **in** **time**, **according to** **this** hypothesis, **lays** **the** foundation **for** **the** emergence **of** autobiographical **memory**.

**A** **third** **possibility** **is** **that** **children** **will** **not** **be** **able** **to** **tell** **their** **own** “**life** **story**” **until** **they** **understand** **something** **about** **the** **general** **form** **stories** **take**, **that** **is**, **the** structure **of** narratives. **Knowledge** **about** narratives **arises** **from** **social** interactions, particularly **the** storytelling **that** **children** **experience** **from** **parents** **and** **the** **attempts** **parents** **make** **to** **talk** **with** **children** **about** **past** **events** **in** **their** **lives**. **When** **parents** **talk** **with** **children** **about** “**what** **we** **did** **today**” **or** “**last** **week**” **or** “**last** **year**,” **they** **guide** **the** **children**’s formation **of** **a** **framework** **for** **talking** **about** **the** **past**. **They** **also** **provide** **children** **with** reminders **about** **the** **memory** **and** **relay** **the** **message** **that** **memories** **are** **valued** **as** **part** **of** **the** cultural **experience**. **It** **is** **interesting** **to** **note** **that** **some** **studies** **show** Caucasian **American** **children** **have** earlier **childhood** **memories** **than** Korean **children** **do**. Furthermore, **other** **studies** **show** **that** Caucasian **American** **mother**-**child** **pairs** **talk** **about** **past** **events** **three** **times** **more** **often** **than** **do** Korean **mother**-**child** **pairs**. **Thus**, **the** **types** **of** **social** **experiences** **children** **have** **do** factor **into** **the** **development** **of** autobiographical **memories**.

**A** **final** **suggestion** **is** **that** **children** must **begin** **to** **develop** **a** “**theory** **of** **mind**”—an awareness **of** **the** **concept** **of** **mental** **states** (**feelings**, **desires**, **beliefs**, **and** **thoughts**), **their** **own** **and** **those** **of** **others**—**before** **they** **can** **talk** **about** **their** **own** **past** **memories**. **Once** **children** **become** capable **of** **answering** **such** **questions** **as** “**What** **does** **it** **mean** **to** **remember**?” **and** “**What** **does** **it** **mean** **to** **know** **something**?” improvements **in** **memory** **seem** **to** **occur**.

**It** may **be** **that** **the** **developments** **just** **described** **are** intertwined **with** **and** **influence** **one** **another**. **Talking** **with** **parents** **about** **the** **past** may enhance **the** **development** **of** **the** **self**-**concept**, **for** **example**, **as** **well** **as** **help** **the** **child** **understand** **what** **it** **means** **to** “**remember**.” **No** **doubt** **the** **ability** **to** **talk** **about** **one**’s **past** **represents** **memory** **of** **a** **different** **level** **of** complexity **than** **simple** recognition **or** recall.

count: 196

# Official 53-Passage 02 Rain Forest Soils

**On** **viewing** **the** lush **plant** **growth** **of** **a** tropical **rain** **forest**, **most** **people** **would** **conclude** **that** **the** **soil** **beneath** **it** **is** **rich** **in** nutrients. **However**, **although** **rain** **forest** **soils** **are** highly variable, **they** **have** **in** **common** **the** **fact** **that** **abundant** **rainfall** **washes** **mineral** nutrients **out** **of** **them** **and** **into** **streams**. **This** **process** **is** **known** **as** leaching. **Because** **of** **rain** leaching, **most** tropical **rain** **forest** **soils** **have** **low** **to** **very** **low** **mineral** nutrient **content**, **in** dramatic contrast **to** **mineral**-**rich** grassland **soils**. Tropical **forest** **soils** **also** **often** **contain** **particular** **types** **of** **clays** **that**, **unlike** **the** **mineral**-binding **clays** **of** temperate **forest** **soils**, **do** **not** bind **mineral** ions **well**. Aluminum **is** **the** dominant cation (positively **charged** ion) **present** **in** tropical **soils**; **but** **plants** **do** **not** **require** **this** element, **and** **it** **is** moderately toxic **to** **a** **wide** **range** **of** **plants**. Aluminum **also** **reduces** **the** availability **of** phosphorus, an element **in** **high** **demand** **by** **plants**.

**High** moisture **and** **temperatures** **speed** **the** **growth** **of** **soil** microbes **that** decompose organic compounds, **so** tropical **soils** typically **contain** **far** lower **amounts** **of** organic **materials** (humus) **than** **do** **other** **forest** **or** grassland **soils**. **Because** organic compounds **help** loosen compact **clay** **soils**, **hold** **water**, **and** bind **mineral** nutrients, **the** **relative** **lack** **of** organic **materials** **in** tropical **soils** **is** deleterious **to** **plants**. **Plant** **roots** cannot penetrate **far** **into** **hard** **clay** **soils**, **and** **during** **dry** **periods**, **the** **soil** cannot **hold** **enough** **water** **to** **supply** **plant** **needs**. **Because** **the** concentration **of** **dark**-colored organic **materials** **is** **low** **in** tropical **soils**, **they** **are** **often** colored **red** **or** **yellow** **by** **the** presence **of** **iron**, aluminum, **and** manganese oxides; **when** **dry**, **these** **soils** **become** **rock** **hard**. **The** **famous** Cambodian **temples** **of** Angkor Wat, **which** **have** **survived** **for** **many** **centuries**, **were** **constructed** **from** **blocks** **of** **such** **hard** **rain** **forest** **soils**.

**Given** **such** **poor** **soils**, **how** **can** lush tropical **forests** **exist**? **The** **answer** **is** **that** **the** **forest**’s **minerals** **are** **held** **in** **its** **living** biomass—**the** **trees** **and** **other** **plants** **and** **the** **animals**. **In** contrast **to** grasslands, **where** **a** **large** proportion **of** **plant** biomass **is** **produced** **underground**, **that** **of** tropical **forests** **is** **nearly** **all** aboveground. **Dead** **leaves**, **branches**, **and** **other** **plant** **parts**, **as** **well** **as** **the** **wastes** **and** bodies **of** **rain** **forest** **animals**, barely **reach** **the** **forest** **floor** **before** **they** **are** rapidly decayed **by** **abundant** decomposers—bacterial **and** fungal. **Minerals** released **by** decay **are** quickly **absorbed** **by** multitudinous **shallow**, **fine** **tree** feeder **roots** **and** **stored** **in** **plant** **tissues**. **Many** tropical **rain** **forest** **plants** (**like** **those** **in** **other** **forests**) **have** mycorrhizal (fungus-**root**) **partners** **whose** **delicate** hyphae **spread** **through** **great** volumes **of** **soil**, **from** **which** **they** release **and** **absorb** **minerals** **and** **ferry** **them** **back** **to** **the** **host** **plant** **in** **exchange** **for** **needed** organic compounds. **The** fungal hyphae **are** **able** **to** **absorb** phosphorus **that** **plant** **roots** **could** **not** **themselves** **obtain** **from** **the** **very** dilute **soil** solutions, **and** fungal hyphae **can** transfer **mineral** nutrients **from** **one** **forest** **plant** **to** **another**. Consequently, tropical **rain** **forests** typically **have** **what** **are** **known** **as** **closed** nutrient **systems**, **in** **which** **minerals** **are** **handed** **off** **from** **one** organism **to** **another** **with** **little** **leaking** **through** **to** **the** **soil**. **When** **mineral** nutrients **do** **not** **spend** **much** **time** **in** **the** **soil**, **they** cannot **be** leached **into** **streams**. **Closed** nutrient **systems** **have** evolved **in** response **to** **the** leaching **effects** **of** **heavy** tropical **rainfall**. **Evidence** **for** **this** **conclusion** **is** **that** nutrient **systems** **are** **more** **open** **in** **the** richest tropical **soils** **and** tightest **in** **the** poorest **soils**.

**The** **growth** **of** organisms **is** dependent **on** **the** availability **of** nutrients, **none** **of** **which** **is** **more** **important** **than** nitrogen. **Although** **there** **is** an **abundant** **supply** **of** nitrogen **in** **Earth**’s **atmosphere**, **it** cannot **be** **absorbed** **by** **plants** **unless** **it** **is** “**fixed**,” **or** **combined** chemically **with** **other** elements **to** **form** nitrogen compounds. Nitrogen-**fixing** **bacteria** **help** tropical **rain** **forest** **plants** cope **with** **the** **poor** **soils** **there** **by** **supplying** **them** **with** **needed** nitrogen. **Many** species **of** tropical **rain** **forest** **trees** **belong** **to** **the** legume **family**, **which** **is** **known** **for** **associations** **of** nitrogen-**fixing** **bacteria** **within** **root** nodules. **Also**, cycads (**a** **type** **of** tropical **plant** **that** **resembles** **a** palm **tree**) **produce** **special** aboveground **roots** **that** harbor nitrogen-**fixing** cyanobacteria. **By** **growing** **above** **the** **ground**, **the** **roots** **are** **exposed** **to** **sunlight**, **which** **the** cyanobacteria **require** **for** **growth**. Nitrogen fixation **by** **free**-**living** **bacteria** **in** tropical **soils** **is** **also** **beneficial**.

count: 195

# Official 27-Passage 02 The Formation of Volcanic Islands

**Earth**’s **surface** **is** **not** **made** **up** **of** **a** **single** **sheet** **of** **rock** **that** **forms** **a** crust **but** **rather** **a** **number** **of** “tectonic **plates**” **that** **fit** closely, **like** **the** **pieces** **of** **a** giant jigsaw **puzzle**. **Some** **plates** **carry** **islands** **or** **continents**; **others** **form** **the** seafloor. **All** **are** slowly **moving** **because** **the** **plates** **float** **on** **a** denser semiliquid mantle, **the** layer **between** **the** crust **and** **Earth**’s core. **The** **plates** **have** **edges** **that** **are** **spreading** ridges (**where** **two** **plates** **are** **moving** **apart** **and** **new** seafloor **is** **being** **created**), subduction **zones** (**where** **two** **plates** collide **and** **one** plunges **beneath** **the** **other**), **or** **transform** **faults** (**where** **two** **plates** **neither** converge **nor** diverge **but** **merely** **move** **past** **one** **another**). **It** **is** **at** **the** **boundaries** **between** **plates** **that** **most** **of** **Earth**’s volcanism **and** **earthquake** **activity** **occur**.

Generally **speaking**, **the** interiors **of** **plates** **are** geologically uneventful. **However**, **there** **are** exceptions. **A** **glance** **at** **a** **map** **of** **the Pacific Ocean** **Ocean** reveals **that** **there** **are** **many** **islands** **far** **out** **at** **sea** **that** **are** actually **volcanoes**—**many** **no** longer **active**, **some** overgrown **with** **coral**—**that** originated **from** **activity** **at** **points** **in** **the** interior **of** **the** **Pacific** **Plate** **that** **forms** **the** **Pacific** seafloor.

**How** **can** volcanic **activity** **occur** **so** **far** **from** **a** **plate** **boundary**? **The** Hawaiian **Islands** **provide** **a** **very** instructive **answer**. **Like** **many** **other** **island** **groups**, **they** **form** **a** **chain**. **The** Hawaiian **Island** **Chain** extends **northwest** **from** **the** **island** **of** Hawaii. **In** **the** 1840s **American** geologist James Daly **observed** **that** **the** **different** Hawaiian **Islands** **seem** **to** **share** **a** **similar** geologic **evolution** **but** **are** progressively **more** eroded, **and** **therefore** **probably** older, **toward** **the** **northwest**. **Then** **in** 1963, **in** **the** **early** **days** **of** **the** **development** **of** **the** **theory** **of** **plate** tectonics, **Canadian** geophysicist Tuzo Wilson realized **that** **this** **age** progression **could** **result** **if** **the** **islands** **were** **formed** **on** **a** **surface** **plate** **moving** **over** **a** **fixed** volcanic source **in** **the** interior. Wilson **suggested** **that** **the** **long** **chain** **of** **volcanoes** stretching **northwest** **from** Hawaii **is** **simply** **the** **surface** **expression** **of** **a** **long**-**lived** volcanic source located **beneath** **the** tectonic **plate** **in** **the** mantle. **Today**’s **most** northwestern **island** **would** **have** **been** **the** **first** **to** **form**. **Then**, **as** **the** **plate** **moved** slowly **northwest**, **new** volcanic **islands** **would** **have** **formed** **as** **the** **plate** **moved** **over** **the** volcanic source. **The** **most** **recent** **island**, Hawaii, **would** **be** **at** **the** **end** **of** **the** **chain** **and** **is** **now** **over** **the** volcanic source.

**Although** **this** **idea** **was** **not** **immediately** **accepted**, **the** **dating** **of** lavas **in** **the** Hawaiian (**and** **other**) **chains** **showed** **that** **their** **ages** **increase** **away** **from** **the** presently **active** **volcano**, **just** **as** Daly **had** **suggested**. Wilson’s **analysis** **of** **these** **data** **is** **now** **a** **central** **part** **of** **plate** tectonics. **Most** **volcanoes** **that** **occur** **in** **the** interiors **of** **plates** **are** **believed** **to** **be** **produced** **by** mantle plumes, columns **of** molten **rock** **that** **rise** **from** **deep** **within** **the** mantle. **A** **volcano** **remains** an **active** “**hot** **spot**” **as** **long** **as** **it** **is** **over** **the** plume. **The** plumes apparently originate **at** **great** **depths**, **perhaps** **as** **deep** **as** **the** **boundary** **between** **the** core **and** **the** mantle, **and** **many** **have** **been** **active** **for** **a** **very** **long** **time**. **The** oldest **volcanoes** **in** **the** Hawaiian **hot**-**spot** trail **have** **ages** **close** **to** 80 **million** **years**. **Other** **islands**, **including** Tahiti **and** **Easter** **Island** **in** **the** **Pacific**, Reunion **and** Mauritius **in** **the** **Indian** **Ocean**, **and** **indeed** **most** **of** **the** **large** **islands** **in** **the** **world**’s **oceans**, **owe** **their** **existence** **to** mantle plumes.

**The** oceanic volcanic **islands** **and** **their** **hot**-**spot** trails **are** **thus** **especially** **useful** **for** geologists **because** **they** **record** **the** **past** locations **of** **the** **plate** **over** **a** **fixed** source. **They** **therefore** **permit** **the** reconstruction **of** **the** **process** **of** seafloor **spreading**, **and** consequently **of** **the** **geography** **of** **continents** **and** **of** **ocean** **basins** **in** **the** **past**. **For** **example**, **given** **the** current **position** **of** **the** **Pacific** **Plate**, Hawaii **is** **above** **the Pacific Ocean** **Ocean** **hot** **spot**. **So** **the** **position** **of** **the** **Pacific** **Plate** 50 **million** **years** **ago** **can** **be** **determined** **by** **moving** **it** **such** **that** **a** 50-**million**-**year**-**old** **volcano** **in** **the** **hot**-**spot** trail **sits** **at** **the** location **of** Hawaii **today**. **However**, **because** **the** **ocean** **basins** **really** **are** **short**-**lived** features **on** geologic **time** scales, reconstructing **the** **world**’s **geography** **by** backtracking **along** **the** **hot**-**spot** trail **works** **only** **for** **the** **last** 5 **percent** **or** **so** **of** geologic **time**.

count: 194

# Official 16-Passage 02 Development of the Periodic Table

**The** periodic **table** **is** **a** **chart** **that** **reflects** **the** periodic recurrence **of** **chemical** **and** **physical** properties **of** **the** elements **when** **the** elements **are** **arranged** **in** **order** **of** **increasing** atomic **number** (**the** **number** **of** protons **in** **the** nucleus). **It** **is** **a** monumental **scientific** **achievement**, **and** **its** **development** illustrates **the** essential interplay **between** observation, prediction, **and** **testing** **required** **for** **scientific** **progress**. **In** **the** 1800’s **scientists** **were** **searching** **for** **new** elements. **By** **the** **late** 1860’s **more** **than** 60 **chemical** elements **had** **been** identified, **and** **much** **was** **known** **about** **their** descriptive **chemistry**. **Various** proposals **were** **put** forth **to** **arrange** **the** elements **into** **groups** **based** **on** similarities **in** **chemical** **and** **physical** properties. **The** **next** **step** **was** **to** recognize **a** **connection** **between** **group** properties (**physical** **or** **chemical** similarities) **and** atomic **mass** (**the** **measured** **mass** **of** an individual **atom** **of** an element). **When** **the** elements **known** **at** **the** **time** **were** **ordered** **by** **increasing** atomic **mass**, **it** **was** **found** **that** successive elements **belonged** **to** **different** **chemical** **groups** **and** **that** **the** **order** **of** **the** **groups** **in** **this** sequence **was** **fixed** **and** **repeated** **itself** **at** **regular** **intervals**. **Thus** **when** **the** series **of** elements **was** **written** **so** **as** **to** **begin** **a** **new** horizontal **row** **with** **each** alkali **metal**, elements **of** **the** **same** **groups** **were** automatically assembled **in** **vertical** columns **in** **a** periodic **table** **of** **the** elements. **This** **table** **was** **the** forerunner **of** **the** **modern** **table**.

**When** **the** **German** **chemist** Lothar Meyer **and** (independently) **the** **Russian** Dmitry Mendeleyev **first** **introduced** **the** periodic **table** **in** 1869-70, **one**-**third** **of** **the** naturally **occurring** **chemical** elements **had** **not** **yet** **been** **discovered**. **Yet** **both** **chemists** **were** sufficiently farsighted **to** **leave** gaps **where** **their** **analyses** **of** periodic **physical** **and** **chemical** properties indicated **that** **new** elements **should** **be** located. Mendeleyev **was** bolder **than** Meyer **and** **even** **assumed** **that** **if** **a** **measured** atomic **mass** **put** an element **in** **the** **wrong** **place** **in** **the** **table**, **the** atomic **mass** **was** **wrong**. **In** **some** **cases** **this** **was** **true**. Indium, **for** **example**, **had** previously **been** assigned an atomic **mass** **between** **those** **of** arsenic **and** selenium. **Because** **there** **is** **no** **space** **in** **the** periodic **table** **between** **these** **two** elements, Mendeleyev **suggested** **that** **the** atomic **mass** **of** indium **be** **changed** **to** **a** completely **different** **value**, **where** **it** **would** **fill** an **empty** **space** **between** cadmium **and** **tin**. **In** **fact**, subsequent **work** **has** **shown** **that** **in** **a** periodic **table**, elements **should** **not** **be** **ordered** strictly **by** atomic **mass**. **For** **example**, tellurium **comes** **before** iodine **in** **the** periodic **table**, **even** **though** **its** atomic **mass** **is** slightly greater. **Such** anomalies **are** **due** **to** **the** **relative** abundance **of** **the** “isotopes” **or** **varieties** **of** **each** element. **All** **the** isotopes **of** **a** **given** element **have** **the** **same** **number** **of** protons, **but** **differ** **in** **their** **number** **of** neutrons, **and** hence **in** **their** atomic **mass**. **The** isotopes **of** **a** **given** element **have** **the** **same** **chemical** properties **but** slightly **different** **physical** properties. **We** **now** **know** **that** atomic **number** (**the** **number** **of** protons **in** **the** nucleus), **not** atomic **mass** **number** (**the** **number** **of** protons **and** neutrons), **determines** **chemical** behavior.

Mendeleyev **went** further **than** Meyer **in** **another** **respect**: **he** **predicted** **the** properties **of** **six** elements **yet** **to** **be** **discovered**. **For** **example**, **a** gap **just** **below** aluminum **suggested** **a** **new** element **would** **be** **found** **with** properties analogous **to** **those** **of** aluminum. Mendeleyev designated **this** element “eka-aluminum” (eka **is** **the** Sanskrit **word** **for** “**next**”) **and** **predicted** **its** properties. **Just** **five** **years** **later** an element **with** **the** **proper** atomic **mass** **was** isolated **and** **named** gallium **by** **its** discoverer. **The** **close** correspondence **between** **the** **observed** properties **of** gallium **and** Mendeleyev’s predictions **for** eka-aluminum **lent** **strong** **support** **to** **the** periodic **law**. **When** elements **are** **arranged** **in** **order** **of** **their** atomic **number**, **most** **of** **the** properties **of** **the** elements reoccur **at** **regular** **intervals**. Additional **support** **came** **in** 1885 **when** eka-silicon, **which** **had** **also** **been** **described** **in** **advance** **by** Mendeleyev, **was** **discovered** **and** **named** germanium.

**The** structure **of** **the** periodic **table** **appeared** **to** **limit** **the** **number** **of** **possible** elements. **It** **was** **therefore** **quite** **surprising** **when** John William Strutt, Lord Rayleigh, **discovered** **a** gaseous element **in** 1894 **that** **did** **not** **fit** **into** **the** previous classification scheme. **A** **century** earlier, Henry Cavendish **had** **noted** **the** **existence** **of** **a** residual **gas** **when** **oxygen** **and** nitrogen **are** **removed** **from** **air**, **but** **its** **importance** **had** **not** **been** realized. **Together** **with** William Ramsay, Rayleigh isolated **the** **gas** (**separating** **it** **from** **other** substances **into** **its** **pure** **state**) **and** **named** **it** argon. Ramsay **then** **studied** **a** **gas** **that** **was** **present** **in** **natural** **gas** **deposits** **and** **discovered** **that** **it** **was** helium, an element **whose** presence **in** **the** **Sun** **had** **been** **noted** earlier **in** **the** spectrum **of** **sunlight** **but** **that** **had** **not** previously **been** **known** **on** **Earth**. Rayleigh **and** Ramsay postulated **the** **existence** **of** **a** **new** **group** **of** elements, **and** **in** 1898 **other** **members** **of** **the** series (neon, krypton, **and** xenon) **were** isolated.

count: 194

# Official 10-Passage 02 Variations in the Climate

**One** **of** **the** **most** **difficult** **aspects** **of** **deciding** **whether** current climatic **events** reveal **evidence** **of** **the** impact **of** **human** **activities** **is** **that** **it** **is** **hard** **to** **get** **a** **measure** **of** **what** constitutes **the** **natural** variability **of** **the** **climate**. **We** **know** **that** **over** **the** **past** millennia **the** **climate** **has** undergone **major** **changes** **without** **any** significant **human** intervention. **We** **also** **know** **that** **the** global **climate** **system** **is** immensely complicated **and** **that** **everything** **is** **in** **some** **way** **connected**, **and** **so** **the** **system** **is** capable **of** fluctuating **in** unexpected **ways**. **We** **need** **therefore** **to** **know** **how** **much** **the** **climate** **can** vary **of** **its** **own** accord **in** **order** **to** interpret **with** confidence **the** extent **to** **which** **recent** **changes** **are** **natural** **as** **opposed** **to** **being** **the** **result** **of** **human** **activities**.

Instrumental **records** **do** **not** **go** **back** **far** **enough** **to** **provide** us **with** **reliable** measurements **of** global climatic variability **on** timescales longer **than** **a** **century**. **What** **we** **do** **know** **is** **that** **as** **we** **include** longer **time** **intervals**, **the** **record** **shows** **increasing** **evidence** **of** **slow** **swings** **in** **climate** **between** **different** regimes. **To** **build** **up** **a** **better** **picture** **of** fluctuations appreciably further **back** **in** **time** **requires** us **to** **use** proxy **records**.

**Over** **long** **periods** **of** **time**, substances **whose** **physical** **and** **chemical** properties **change** **with** **the** ambient **climate** **at** **the** **time** **can** **be** **deposited** **in** **a** **systematic** **way** **to** **provide** **a** continuous **record** **of** **changes** **in** **those** properties **over** **time**, **sometimes** **for** **hundreds** **or** **thousands** **of** **years**. Generally, **the** layering **occurs** **on** an **annual** **basis**, hence **the** **observed** **changes** **in** **the** **records** **can** **be** **dated**. **Information** **on** **temperature**, **rainfall**, **and** **other** **aspects** **of** **the** **climate** **that** **can** **be** inferred **from** **the** **systematic** **changes** **in** properties **is** **usually** **referred** **to** **as** proxy **data**. Proxy **temperature** **records** **have** **been** reconstructed **from** **ice** core **drilled** **out** **of** **the** **central** Greenland **ice** **cap**, calcite shells embedded **in** layered **lake** sediments **in** **Western** **Europe**, **ocean** **floor** sediment cores **from** **the** tropical **Atlantic** **Ocean**, **ice** cores **from** Peruvian glaciers, **and** **ice** cores **from** **eastern** **Antarctica**. **While** **these** **records** **provide** broadly **consistent** indications **that** **temperature** variations **can** **occur** **on** **a** global scale, **there** **are** nonetheless **some** intriguing **differences**, **which** **suggest** **that** **the** **pattern** **of** **temperature** variations **in** regional **climates** **can** **also** **differ** significantly **from** **each** **other**.

**What** **the** proxy **records** **make** abundantly **clear** **is** **that** **there** **have** **been** significant **natural** **changes** **in** **the** **climate** **over** timescales longer **than** **a** **few** **thousand** **years**. Equally **striking**, **however**, **is** **the** **relative** stability **of** **the** **climate** **in** **the** **past** 10,000 **years** (**the** Holocene **period**).

**To** **the** extent **that** **the** coverage **of** **the** global **climate** **from** **these** **records** **can** **provide** **a** **measure** **of** **its** **true** variability, **it** **should** **at** **least** indicate **how** **all** **the** **natural** **causes** **of** **climate** **change** **have** **combined**. **These** **include** **the** chaotic fluctuations **of** **the** **atmosphere**, **the** slower **but** equally erratic behavior **of** **the** **oceans**, **changes** **in** **the** **land** **surfaces**, **and** **the** extent **of** **ice** **and** **snow**. **Also** **included** **will** **be** **any** variations **that** **have** **arisen** **from** volcanic **activity**, **solar** **activity**, **and**, **possibly**, **human** **activities**.

**One** **way** **to** estimate **how** **all** **the** **various** **processes** **leading** **to** **climate** variability **will** **combine** **is** **by** **using** **computer** **models** **of** **the** global **climate**. **They** **can** **do** **only** **so** **much** **to** **represent** **the** **full** complexity **of** **the** global **climate** **and** hence may **give** **only** **limited** **information** **about** **natural** variability. **Studies** **suggest** **that** **to** **date** **the** variability **in** **computer** simulations **is** considerably smaller **than** **in** **data** **obtained** **from** **the** proxy **records**.

**In** **addition** **to** **the** internal variability **of** **the** global **climate** **system** **itself**, **there** **is** **the** **added** factor **of** external **influences**, **such** **as** **volcanoes** **and** **solar** **activity**. **There** **is** **a** **growing** body **of** **opinion** **that** **both** **these** **physical** variations **have** **a** measurable impact **on** **the** **climate**. **Thus** **we** **need** **to** **be** **able** **to** **include** **these** **in** **our** deliberations. **Some** current **analyses** **conclude** **that** **volcanoes** **and** **solar** **activity** **explain** **quite** **a** considerable **amount** **of** **the** **observed** variability **in** **the** **period** **from** **the** seventeenth **to** **the** **early** **twentieth** **centuries**, **but** **that** **they** cannot **be** invoked **to** **explain** **the** **rapid** **warming** **in** **recent** **decades**.

count: 194

# Official 38-Passage 03 Transgenic Plants

Genes **from** virtually **any** organism, **from** **viruses** **to** **humans**, **can** **now** **be** **inserted** **into** **plants**, **creating** **what** **are** **known** **as** transgenic **plants**. **Now** **used** **in** **agriculture**, **there** **are** **approximately** 109 **million** **acres** **of** transgenic **crops** **grown** **worldwide**, 68 **percent** **of** **which** **are** **in** **the** **United** **States**. **The** **most** **common** transgenic **crops** **are** soybeans, **corn**, **cotton**, **and** canola. **Most** **often**, **these** **plants** **either** **contain** **a** gene **making** **them** resistant **to** **the** herbicide glyphosate **or** **they** **contain** an **insect**-resistant gene **that** **produces** **a** protein **called** Bt toxin.

**On** **the** positive **side**, proponents **of** transgenic **crops** **argue** **that** **these** **crops** **are** environmentally **friendly** **because** **they** **allow** **farmers** **to** **use** fewer **and** **less** noxious **chemicals** **for** **crop** **production**. **For** **example**, **a** 21 **percent** reduction **in** **the** **use** **of** insecticide **has** **been** **reported** **on** Bt **cotton** (transgenic **cotton** **that** **produces** Bt toxin). **In** **addition**, **when** glyphosate **is** **used** **to** **control** **weeds**, **other**, **more** persistent herbicides **do** **not** **need** **to** **be** **applied**.

**On** **the** negative **side**, opponents **of** transgenic **crops** **suggest** **that** **there** **are** **many** **questions** **that** **need** **to** **be** **answered** **before** transgenic **crops** **are** **grown** **on** **a** **large** scale. **One** **question** **deals** **with** **the** **effects** **that** Bt **plants** **have** **on** nontarget organisms **such** **as** **beneficial** **insects**, **worms**, **and** **birds** **that** **consume** **the** genetically **engineered** **crop**. **For** **example**, monarch caterpillars **feeding** **on** milkweed **plants** **near** Bt cornfields **will** **eat** **some** **corn** pollen **that** **has** **fallen** **on** **the** milkweed **leaves**. Laboratory **studies** indicate **that** caterpillars **can** **die** **from** **eating** Bt pollen. **However**, **field** **tests** indicate **that** Bt **corn** **is** **not** **likely** **to** **harm** monarchs. Furthermore, **the** **application** **of** pesticides (**the** **alternative** **to** **growing** Bt **plants**) **has** **been** demonstrated **to** **cause** **widespread** **harm** **to** nontarget **insects**.

**Another** unanswered **question** **is** **whether** herbicide-resistant genes **will** **move** **into** **the** **populations** **of** **weeds**. **Crop** **plants** **are** **sometimes** **grown** **in** **areas** **where** weedy **relatives** **also** **live**. **If** **the** **crop** **plants** hybridize **and** reproduce **with** weedy **relatives**, **then** **this** herbicide-resistant gene **will** **be** perpetuated **in** **the** offspring. **In** **this** **way**, **the** resistant gene **can** **make** **its** **way** **into** **the** **weed** **population**. **If** **this** **happens**, **a** **farmer** **can** **no** longer **use** glyphosate, **for** **example**, **to** **kill** **those** **weeds**. **This** scenario **is** **not** **likely** **to** **occur** **in** **many** instances **because** **there** **are** **no** weedy **relatives** **growing** **near** **the** **crop** **plant**. **However**, **in** **some** **cases**, **it** may **become** **a** **serious** **problem**. **For** **example**, canola readily hybridizes **with** **mustard** **weed** species **and** **could** transfer **its** herbicide-resistant genes **to** **those** **weeds**.

**We** **know** **that** **evolution** **will** **occur** **when** transgenic **plants** **are** **grown** **on** **a** **large** scale **over** **a** **period** **of** **time**. **Of** **special** **concern** **is** **the** **development** **of** **insect** **populations** resistant **to** **the** Bt toxin. **This** pesticide **has** **been** **applied** **to** **plants** **for** **decades** **without** **the** **development** **of** **insect**-resistant **populations**. **However**, transgenic Bt **plants** **express** **the** toxin **in** **all** **tissues** **throughout** **the** **growing** **season**. **Therefore**, **all** **insects** **carrying** genes **that** **make** **them** susceptible **to** **the** toxin **will** **die**. **That** **leaves** **only** **the** genetically resistant **insects** **alive** **to** perpetuate **the** **population**. **When** **these** resistant **insects** mate, **they** **will** **produce** **a** **high** proportion **of** offspring capable **of** **surviving** **in** **the** presence **of** **the** Bt toxin. **Farmers** **are** **attempting** **to** **slow** **the** **development** **of** **insect** resistance **in** Bt **crops** **by**, **for** **example**, **planting** nontransgenic **border** **rows** **to** **provide** **a** refuge **for** susceptible **insects**. **These** **insects** may **allow** Bt susceptibility **to** **remain** **in** **the** **population**.

**Perhaps** **the** **most** **serious** **concern** **about** **the** transgenic **crop** **plants** currently **in** **use** **is** **that** **they** **encourage** **farmers** **to** **move** farther **away** **from** sustainable **agricultural** **farming** **practices**, **meaning** **ones** **that** **allow** **natural** resources **to** continually regenerate **over** **the** **long** **run**. Transgenics, **at** **least** superficially, **simplify** **farming** **by** **reducing** **the** **choices** **made** **by** **the** **manager**. **Planting** **a** glyphosate-resistant **crop** **commits** **a** **farmer** **to** **using** **that** herbicide **for** **the** **season**, **probably** **to** **the** exclusion **of** **all** **other** herbicides **and** **other** **weed**-**control** **practices**. **Farmers** **who** **use** Bt transgenics may **not** **feel** **that** **they** **need** **to** **follow** **through** **with** integrated **pest**-management **practices** **that** **use** **beneficial** **insects** **and** timely **applications** **of** pesticides **to** **control** **insect** **pests**. **A** **more** sustainable **approach** **would** **be** **to** **plant** nontransgenic **corn**, **monitor** **the** **fields** **throughout** **the** **growing** **season**, **and** **then** **apply** **a** pesticide **only** **if** **and** **when** **needed**.

count: 193

# Official 44-Passage 03 Seagrasses

**Many** **areas** **of** **the** **shallow** **sea** **bottom** **are** **covered** **with** **a** lush **growth** **of** aquatic **flowering** **plants** **adapted** **to** **live** submerged **in** seawater. **These** **plants** **are** collectively **called** seagrasses. Seagrass **beds** **are** strongly **influenced** **by** **several** **physical** factors. **The** **most** significant **is** **water** motion: currents **and** **waves**. **Since** seagrass **systems** **exist** **in** **both** **sheltered** **and** relatively **open** **areas**, **they** **are** **subject** **to** **differing** **amounts** **of** **water** motion. **For** **any** **given** seagrass **system**, **however**, **the** **water** motion **is** relatively **constant**. Seagrass meadows **in** relatively turbulent **waters** **tend** **to** **form** **a** mosaic **of** individual mounds, whereas meadows **in** relatively **calm** **waters** **tend** **to** **form** **flat**, extensive **carpets**. **The** seagrass **beds**, **in** **turn**, dampen **wave** **action**, particularly **if** **the** blades **reach** **the** **water** **surface**. **This** **damping** **effect** **can** **be** significant **to** **the** **point** **where** **just** **one** meter **into** **a** seagrass **bed** **the** **wave** motion **can** **be** **reduced** **to** **zero**. Currents **are** **also** **slowed** **as** **they** **move** **into** **the** **bed**.

**The** **slowing** **of** **wave** **action** **and** currents **means** **that** seagrass **beds** **tend** **to** **accumulate** sediment. **However**, **this** **is** **not** **universal** **and** **depends** **on** **the** currents **under** **which** **the** **bed** **exists**. Seagrass **beds** **under** **the** **influence** **of** **strong** currents **tend** **to** **have** **many** **of** **the** lighter particles, **including** seagrass debris, **moved** **out**, whereas **beds** **in** **weak** current **areas** **accumulate** lighter detrital **material**. **It** **is** **interesting** **that** temperate seagrass **beds** **accumulate** sediments **from** sources **outside** **the** **beds**, whereas tropical seagrass **beds** derive **most** **of** **their** sediments **from** **within**.

**Since** **most** seagrass **systems** **are** depositional **environments**, **they** **eventually** **accumulate** organic **material** **that** **leads** **to** **the** creation **of** **fine**-**grained** sediments **with** **a** **much** higher organic **content** **than** **that** **of** **the** **surrounding** unvegetated **areas**. **This** accumulation, **in** **turn**, **reduces** **the** **water** **movement** **and** **the** **oxygen** **supply**. **The** **high** **rate** **of** metabolism (**the** **processing** **of** energy **for** **survival**) **of** **the** microorganisms **in** **the** sediments **causes** sediments **to** **be** anaerobic (**without** **oxygen**) **below** **the** **first** **few** millimeters. **According to** ecologist J. W. Kenworthy, anaerobic **processes** **of** **the** microorganisms **in** **the** sediment **are** an **important** mechanism **for** regenerating **and** **recycling** nutrients **and** **carbon**, ensuring **the** **high** **rates** **of** productivity—**that** **is**, **the** **amount** **of** organic **material** **produced**—**that** **are** **measured** **in** **those** **beds**. **In** contrast **to** **other** productivity **in** **the** **ocean**, **which** **is** confined **to** **various** species **of** algae **and** **bacteria** dependent **on** nutrient concentrations **in** **the** **water** column, seagrasses **are** **rooted** **plants** **that** **absorb** nutrients **from** **the** sediment **or** substrate. **They** **are**, **therefore**, capable **of** **recycling** nutrients **into** **the** ecosystem **that** **would** **otherwise** **be** **trapped** **in** **the** **bottom** **and** rendered unavailable.

**Other** **physical** factors **that** **have** an **effect** **on** seagrass **beds** **include** **light**, **temperature**, **and** desiccation (**drying** **out**). **For** **example**, **water** **depth** **and** turbidity (density **of** particles **in** **the** **water**) **together** **or** **separately** **control** **the** **amount** **of** **light** **available** **to** **the** **plants** **and** **the** **depth** **to** **which** **the** seagrasses may extend. **Although** marine botanist W. **A**. Setchell **suggested** **early** **on** **that** **temperature** **was** critical **to** **the** **growth** **and** reproduction **of** eelgrass, **it** **has** **since** **been** **shown** **that** **this** particularly **widespread** seagrass **grows** **and** reproduces **at** **temperatures** **between** 2 **and** 4 **degrees** Celsius **in** **the Arctic** **and** **at** **temperatures** **up** **to** 28 **degrees** Celsius **on** **the** northeastern **coast** **of** **the** **United** **States**. **Still**, **extreme** **temperatures**, **in** combination **with** **other** factors, may **have** dramatic detrimental **effects**. **For** **example**, **in** **areas** **of** **the** **cold** **North** **Atlantic**, **ice** may **form** **in** **winter**. Researchers Robertson **and** Mann **note** **that** **when** **the** **ice** **begins** **to** **break** **up**, **the** **wind** **and** tides may **move** **the** **ice** **around**, scouring **the** **bottom** **and** uprooting **the** eelgrass. **In** contrast, **at** **the** **southern** **end** **of** **the** eelgrass **range**, **on** **the** southeastern **coast** **of** **the** **United** **States**, **temperatures** **over** 30 **degrees** Celsius **in** **summer** **cause** excessive mortality. Seagrass **beds** **also** **decline** **if** **they** **are** **subjected** **to** **too** **much** exposure **to** **the** **air**. **The** **effect** **of** desiccation **is** **often** **difficult** **to** **separate** **from** **the** **effect** **of** **temperature**. **Most** seagrass **beds** **seem** tolerant **of** considerable **changes** **in** salinity (**salt** **levels**) **and** **can** **be** **found** **in** brackish (somewhat **salty**) **waters** **as** **well** **as** **in** **full**-**strength** seawater.

count: 193

# Official 40-Passage 02 Latitude and Biodiversity

**When** **we** **look** **at** **the** **way** **in** **which** biodiversity (biological diversity) **is** **distributed** **over** **the** **land** **surface** **of** **the** **planet**, **we** **find** **that** **it** **is** **far** **from** **even**. **The** tropics **contain** **many** **more** species overall **than** an equivalent **area** **at** **the** higher latitudes. **This** **seems** **to** **be** **true** **for** **many** **different** **groups** **of** **animals** **and** **plants**.

**Why** **is** **it** **that** higher latitudes **have** lower diversities **than** **the** tropics? **Perhaps** **it** **is** **simply** **a** **matter** **of** **land** **area**. **The** tropics **contain** **a** larger **surface** **area** **of** **land** **than** higher latitudes—**a** **fact** **that** **is** **not** **always** **evident** **when** **we** **examine** commonly **used** projections **of** **Earth**’s curved **surface**, **since** **this** **tends** **to** exaggerate **the** **areas** **of** **land** **in** **the** higher latitudes—**and** **some** biogeographers **regard** **the** **differences** **in** diversity **as** **a** reflection **of** **this** **effect**. **But** an **analysis** **of** **the** **data** **by** biologist Klaus Rohde **does** **not** **support** **this** **explanation**. **Although** **area** may **contribute** **to** biodiversity, **it** **is** **certainly** **not** **the** **whole** **story**; **otherwise**, **large** landmasses **would** **always** **be** richer **in** species.

Productivity **seems** **to** **be** involved **instead**, **though** **perhaps** **its** **influence** **is** indirect. **Where** **conditions** **are** **most** **suitable** **for** **plant** **growth**—**that** **is**, **where** **temperatures** **are** relatively **high** **and** **uniform** **and** **where** **there** **is** an **ample** **supply** **of** **water**—**one** **usually** **finds** **large** **masses** **of** vegetation. **This** **leads** **to** **a** **complex** structure **in** **the** layers **of** **plant** **material**. **In** **a** tropical **rain** **forest**, **for** **example**, **a** **very** **large** **quantity** **of** **plant** **material** **builds** **up** **above** **the** **surface** **of** **the** **ground**. **There** **is** **also** **a** **large** **mass** **of** **material**, **developed** **below** **ground** **as** **root** **tissues**, **but** **this** **is** **less** **apparent**. **Careful** **analysis** **of** **the** aboveground **material** reveals **that** **it** **is** **arranged** **in** **a** series **of** layers, **the** **precise** **number** **of** layers varying **with** **age** **and** **the** **nature** **of** **the** **forest**. **The** **arrangement** **of** **the** biological **mass** (“biomass”) **of** **the** vegetation **into** layered **forms** **is** **termed** **its** “structure” (**as** **opposed** **to** **its** “**composition**,” **which** **refers** **to** **the** species **of** organisms **forming** **the** community). Structure **is** essentially **the** **architecture** **of** vegetation, **and** **as** **in** **the** **case** **of** **some** tropical **forests**, **it** **can** **be** **extremely** complicated. **In** **a** **mature** floodplain tropical **forest** **in** **the** Amazon **River** **basin**, **the** canopy (**the** uppermost layers **of** **a** **forest**, **formed** **by** **the** crowns **of** **trees**) **takes** **on** **a** stratified structure. **There** **are** **three** **clear** peaks **in** **leaf** **cover** **at** **heights** **of** **approximately** 3, 6, **and** 30 meters **above** **the** **ground**; **and** **the** **very** highest layer, **at** 50 meters, **corresponds** **to** **the** **very** **tall** **trees** **that** **stand** **free** **of** **the** **main** canopy **and** **form** an **open** layer **of** **their** **own**. **So**, **such** **a** **forest** **contains** essentially **four** layers **of** canopy. **Forests** **in** temperate **lands** **often** **have** **just** **two** canopy layers, **so** **they** **have** **much** **less** **complex** **architecture**.

Structure **has** **a** **strong** **influence** **on** **the** **animal** **life** inhabiting **a** site. **It** **forms** **the** spatial **environment** **within** **which** an **animal** **feeds**, **moves** **around**, **shelters**, **lives**, **and** breeds. **It** **even** **affects** **the** **climate** **on** **a** **very** **local** **level** (**the** “microclimate”) **by** **influencing** **light** intensity, humidity, **and** **both** **the** **range** **and** **extremes** **of** **temperature**. An **area** **of** grassland vegetation **with** **very** **simple** structure, **for** **example**, **has** **a** **very** **different** microclimate **at** **the** **ground** **level** **from** **that** **experienced** **in** **the** **upper** canopy. **Wind** **speeds** **are** lower, **temperatures** **are** lower **during** **the** **day** (**but** warmer **at** **night**), **and** **the** **relative** humidity **is** **much** greater **near** **the** **ground**. **The** complexity **of** **the** microclimate **is** closely **related** **to** **the** complexity **of** structure **in** vegetation, **and** generally **speaking**, **the** **more** **complex** **the** structure **of** vegetation, **the** **more** species **of** **animal** **are** **able** **to** **make** **a** **living** **there**. **The** **high** **plant** biomass **of** **the** tropics **leads** **to** **a** greater spatial complexity **in** **the** **environment**, **and** **this** **leads** **to** **a** higher **potential** **for** diversity **in** **the** **living** **things** **that** **can** occupy **a** region. **The** **climates** **of** **the** higher latitudes **are** generally **less** favorable **for** **the** accumulation **of** **large** **quantities** **of** biomass; hence, **the** structure **of** vegetation **is** simpler **and** **the** **animal** diversity **is** consequently lower.

count: 193

# Official 34-Passage 01 Protection of Plants by Insects

**Many** **plants**—**one** **or** **more** species **of** **at** **least** 68 **different** **families**—**can** secrete nectar **even** **when** **they** **have** **no** blossoms, **because** **they** **bear** extrafloral nectaries (structures **that** **produce** nectar) **on** stems, **leaves**, **leaf** stems, **or** **other** structures. **These** **plants** **usually** **occur** **where** **ants** **are** **abundant**, **most** **in** **the** tropics **but** **some** **in** temperate **areas**. **Among** **those** **of** northeastern **North** **America** **are** **various** plums, cherries, **roses**, hawthorns, poplars, **and** oaks. **Like** floral nectar, extrafloral nectar **consists** mainly **of** **water** **with** **a** **high** **content** **of** dissolved **sugars** **and**, **in** **some** **plants**, **small** **amounts** **of** amino **acids**. **The** extrafloral nectaries **of** **some** **plants** **are** **known** **to** **attract** **ants** **and** **other** **insects**, **but** **the** evolutionary **history** **of** **most** **plants** **with** **these** nectaries **is** **unknown**. Nevertheless, **most** ecologists **believe** **that** **all** extrafloral nectaries **attract** **insects** **that** **will** **defend** **the** **plant**.

**Ants** **are** **probably** **the** **most** **frequent** **and** **certainly** **the** **most** persistent defenders **of** **plants**. **Since** **the** highly **active** **worker** **ants** **require** **a** **great** **deal** **of** energy, **plants** **exploit** **this** **need** **by** **providing** extrafloral nectar **that** **supplies** **ants** **with** **abundant** energy. **To** **return** **this** favor, **ants** **guard** **the** nectaries, **driving** **away** **or** **killing** intruding **insects** **that** **might** **compete** **with** **ants** **for** nectar. **Many** **of** **these** intruders **are** herbivorous **and** **would** **eat** **the** **leaves** **of** **the** **plants**.

Biologists **once** **thought** **that** secretion **of** extrafloral nectar **has** **some** purely internal physiological **function**, **and** **that** **ants** **provide** **no** **benefit** whatsoever **to** **the** **plants** **that** secrete **it**. **This** **view** **and** **the** **opposing** “protectionist” hypothesis **that** **ants** **defend** **plants** **had** **been** disputed **for** **over** **a** **hundred** **years** **when**, **in** 1910, **a** skeptical William Morton Wheeler **commented** **on** **the** controversy. **He** **called** **for** proof **of** **the** protectionist **view**: **that** visitations **of** **the** **ants** confer **protection** **on** **the** **plants** **and** **that** **in** **the** **absence** **of** **the** **insects** **a** **much** greater **number** **would** perish **or** **fail** **to** **produce** **flowers** **or** **seeds** **than** **when** **the** **insects** **are** **present**. **That** **we** **now** **have** an abundance **of** **the** proof **that** **was** **called** **for** **was** established **when** Barbara Bentley **reviewed** **the** **relevant** **evidence** **in** 1977, **and** **since** **then** **many** **more** observations **and** **experiments** **have** **provided** **still** further proof **that** **ants** **benefit** **plants**.

**One** **example** **shows** **how** **ants** **attracted** **to** extrafloral nectaries **protect** **morning** **glories** **against** **attacking** **insects**. **The** principal **insect** **enemies** **of** **the** **North** **American** **morning** **glory** **feed** mainly **on** **its** **flowers** **or** **fruits** **rather** **than** **its** **leaves**. Grasshoppers **feeding** **on** **flowers** indirectly **block** pollination **and** **the** **production** **of** **seeds** **by** **destroying** **the** corolla **or** **the** stigma, **which** **receives** **the** pollen **grains** **and** **on** **which** **the** pollen germinates. **Without** **their** colorful corolla, **flowers** **do** **not** **attract** pollinators **and** **are** **not** fertilized. An **adult** grasshopper **can** **consume** **a** **large** corolla, **about** 2.5 **inches** **long**, **in** an **hour**. Caterpillars **and** **seed** beetles **affect** **seed** **production** directly. Caterpillars devour **the** ovaries, **where** **the** **seeds** **are** **produced**, **and** **seed** beetle larvae **eat** **seeds** **as** **they** burrow **in** **developing** **fruits**.

Extrafloral nectaries **at** **the** **base** **of** **each** sepal **attract** **several** **kinds** **of** **insects**, **but** 96 **percent** **of** **them** **are** **ants**, **several** **different** species **of** **them**. **When** buds **are** **still** **small**, **less** **than** **a** **quarter** **of** an **inch** **long**, **the** sepal nectaries **are** **already** **present** **and** **producing** nectar. **They** **continue** **to** **do** **so** **as** **the** **flower** **develops** **and** **while** **the** **fruit** **matures**. Observations **leave** **little** **doubt** **that** **ants** **protect** **morning** **glory** **flowers** **and** **fruits** **from** **the** **combined** **enemy** **force** **of** grasshoppers, caterpillars, **and** **seed** beetles. Bentley **compared** **the** **seed** **production** **of** **six** **plants** **that** **grew** **where** **there** **were** **no** **ants** **with** **that** **of** **seventeen** **plants** **that** **were** occupied **by** **ants**. Unprotected **plants** **bore** **only** 45 **seeds** **per** **plant**, **but** **plants** occupied **by** **ants** **bore** 211 **seeds** **per** **plant**. **Although** **ants** **are** **not** **big** **enough** **to** **kill** **or** seriously **injure** grasshoppers, **they** **drive** **them** **away** **by** nipping **at** **their** **feet**. **Seed** beetles **are** **more** vulnerable **because** **they** **are** **much** smaller **than** grasshoppers. **The** **ants** prey **on** **the** **adult** beetles, **disturb** **females** **as** **they** **lay** **their** **eggs** **on** **developing** **fruits**, **and** **eat** **many** **of** **the** **eggs** **they** **do** **manage** **to** **lay**.

count: 193

# Official 20-Passage 03 Fossil Preservation

**When** **one** **considers** **the** **many** **ways** **by** **which** organisms **are** completely **destroyed** after **death**, **it** **is** remarkable **that** fossils **are** **as** **common** **as** **they** **are**. **Attack** **by** scavengers **and** **bacteria**, **chemical** decay, **and** destruction **by** erosion **and** **other** geologic **agencies** **make** **the** odds **against** preservation **very** **high**. **However**, **the** **chances** **of** **escaping** **complete** destruction **are** vastly **improved** **if** **the** organism **happens** **to** **have** **a** mineralized skeleton **and** **dies** **in** **a** **place** **where** **it** **can** **be** quickly **buried** **by** sediment. **Both** **of** **these** **conditions** **are** **often** **found** **on** **the** **ocean** **floors**, **where** shelled invertebrates (organisms **without** spines) flourish **and** **are** **covered** **by** **the** continuous **rain** **of** sedimentary particles. **Although** **most** fossils **are** **found** **in** marine sedimentary **rocks**, **they** **also** **are** **found** **in** terrestrial **deposits** **left** **by** **streams** **and** **lakes**. **On** occasion, **animals** **and** **plants** **have** **been** **preserved** after **becoming** immersed **in** tar **or** quicksand, **trapped** **in** **ice** **or** lava **flows**, **or** engulfed **by** **rapid** **falls** **of** volcanic **ash**.

**The** **term** “fossil” **often** implies petrifaction, literally **a** transformation **into** **stone**. After **the** **death** **of** an organism, **the** **soft** **tissue** **is** ordinarily **consumed** **by** scavengers **and** **bacteria**. **The** **empty** shell **of** **a** snail **or** clam may **be** **left** **behind**, **and** **if** **it** **is** sufficiently durable **and** resistant **to** dissolution, **it** may **remain** basically unchanged **for** **a** **long** **period** **of** **time**. **Indeed**, unaltered shells **of** marine invertebrates **are** **known** **from** **deposits** **over** 100 **million** **years** **old**. **In** **many** marine **creatures**, **however**, **the** skeleton **is** composed **of** **a** **mineral** **variety** **of** calcium carbonate **called** aragonite. **Although** aragonite **has** **the** **same** **composition** **as** **the** **more** **familiar** **mineral** **known** **as** calcite, **it** **has** **a** **different** crystal **form**, **is** relatively unstable, **and** **in** **time** **changes** **to** **the** **more** **stable** calcite.

**Many** **other** **processes** may alter **the** shell **of** **a** clam **or** snail **and** enhance **its** **chances** **for** preservation. **Water** **containing** dissolved silica, calcium carbonate, **or** **iron** may **circulate** **through** **the** enclosing sediment **and** **be** **deposited** **in** cavities **such** **as** marrow cavities **and** **canals** **in** **bone** **once** occupied **by** **blood** vessels **and** nerves. **In** **such** **cases**, **the** original **composition** **of** **the** **bone** **or** shell **remains**, **but** **the** fossil **is** **made** harder **and** **more** durable. **This** **addition** **of** **a** chemically precipitated substance **into** pore **spaces** **is** **termed** “permineralization.”

Petrifaction may **also** involve **a** simultaneous **exchange** **of** **the** original substance **of** **a** **dead** **plant** **or** **animal** **with** **mineral** **matter** **of** **a** **different** **composition**. **This** **process** **is** **termed** “replacement” **because** solutions **have** dissolved **the** original **material** **and** **replaced** **it** **with** an **equal** volume **of** **the** **new** substance. Replacement **can** **be** **a** marvelously **precise** **process**, **so** **that** details **of** shell ornamentation, **tree** **rings** **in** **wood**, **and** **delicate** structures **in** **bone** **are** accurately **preserved**.

**Another** **type** **of** fossilization, **known** **as** carbonization, **occurs** **when** **soft** **tissues** **are** **preserved** **as** **thin** **films** **of** **carbon**. **Leaves** **and** **tissue** **of** **soft**-bodied organisms **such** **as** jellyfish **or** **worms** may **accumulate**, **become** **buried** **and** compressed, **and** **lose** **their** volatile constituents. **The** **carbon** **often** **remains** **behind** **as** **a** blackened silhouette.

**Although** **it** **is** **certainly** **true** **that** **the** **possession** **of** **hard** **parts** enhances **the** prospect **of** preservation, organisms **having** **soft** **tissues** **and** **organs** **are** **also** occasionally **preserved**. **Insects** **and** **even** **small** invertebrates **have** **been** **found** **preserved** **in** **the** hardened resins **of** conifers **and** **certain** **other** **trees**. **X-ray** examination **of** **thin** slabs **of** **rock** **sometimes** reveals **the** ghostly **outlines** **of** tentacles, digestive tracts, **and** **visual** **organs** **of** **a** **variety** **of** marine **creatures**. **Soft** **parts**, **including** **skin**, **hair**, **and** viscera **of** **ice** **age** mammoths, **have** **been** **preserved** **in** **frozen** **soil** **or** **in** **the** oozing tar **of** **oil** seeps.

**The** probability **that** **actual** **remains** **of** **soft** **tissue** **will** **be** **preserved** **is** **improved** **if** **the** organism **dies** **in** an **environment** **of** **rapid** deposition **and** **oxygen** deprivation. **Under** **such** **conditions**, **the** destructive **effects** **of** **bacteria** **are** diminished. **The** **Middle** Eocene Messel Shale (**from** **about** 48 **million** **years** **ago**) **of** **Germany** **accumulated** **in** **such** an **environment**. **The** shale **was** **deposited** **in** an **oxygen**-deficient **lake** **where** lethal **gases** **sometimes** bubbled **up** **and** **killed** **animals**. **Their** **remains** **accumulated** **on** **the** **floor** **of** **the** **lake** **and** **were** **then** **covered** **by** **clay** **and** silt. **Among** **the** superbly **preserved** Messel fossils **are** **insects** **with** iridescent exoskeletons (**hard** **outer** coverings), **frogs** **with** **skin** **and** **blood** vessels intact, **and** **even** **entire** **small** mammals **with** **preserved** **fur** **and** **soft** **tissue**.

count: 193

# Official 03-Passage 03 The Long-Term Stability of Ecosystems

**Plant** communities assemble **themselves** flexibly, **and** **their** **particular** structure **depends** **on** **the** **specific** **history** **of** **the** **area**. Ecologists **use** **the** **term** “succession” **to** **refer** **to** **the** **changes** **that** **happen** **in** **plant** communities **and** ecosystems **over** **time**. **The** **first** community **in** **a** succession **is** **called** **a** **pioneer** community, **while** **the** **long**-**lived** community **at** **the** **end** **of** succession **is** **called** **a** climax community. **Pioneer** **and** successional **plant** communities **are** **said** **to** **change** **over** **periods** **from** 1 **to** 500 **years**. **These** **changes**—**in** **plant** **numbers** **and** **the** **mix** **of** species—**are** cumulative. Climax communities **themselves** **change** **but** **over** **periods** **of** **time** greater **than** **about** 500 **years**.

An ecologist **who** **studies** **a** **pond** **today** may **well** **find** **it** relatively unchanged **in** **a** **year**’s **time**. Individual **fish** may **be** **replaced**, **but** **the** **number** **of** **fish** **will** **tend** **to** **be** **the** **same** **from** **one** **year** **to** **the** **next**. **We** **can** **say** **that** **the** properties **of** an ecosystem **are** **more** **stable** **than** **the** individual organisms **that** compose **the** ecosystem.

**At** **one** **time**, ecologists **believed** **that** species diversity **made** ecosystems **stable**. **They** **believed** **that** **the** greater **the** diversity **the** **more** **stable** **the** ecosystem. **Support** **for** **this** **idea** **came** **from** **the** observation **that** **long**-**lasting** climax communities **usually** **have** **more** **complex** **food** **webs** **and** **more** species diversity **than** **pioneer** communities. Ecologists **concluded** **that** **the** **apparent** stability **of** climax ecosystems **depended** **on** **their** complexity. **To** **take** an **extreme** **example**, farmlands dominated **by** **a** **single** **crop** **are** **so** unstable **that** **one** **year** **of** **bad** **weather** **or** **the** invasion **of** **a** **single** **pest** **can** **destroy** **the** **entire** **crop**. **In** contrast, **a** **complex** climax community, **such** **as** **a** temperate **forest**, **will** **tolerate** considerable **damage** **from** **weather** **or** **pests**.

**The** **question** **of** ecosystem stability **is** complicated, **however**. **The** **first** **problem** **is** **that** ecologists **do** **not** **all** **agree** **what** “stability” **means**. Stability **can** **be** defined **as** **simply** **lack** **of** **change**. **In** **that** **case**, **the** climax community **would** **be** **considered** **the** **most** **stable**, **since**, **by** definition, **it** **changes** **the** **least** **over** **time**. Alternatively, stability **can** **be** defined **as** **the** **speed** **with** **which** an ecosystem **returns** **to** **a** **particular** **form** **following** **a** **major** disturbance, **such** **as** **a** **fire**. **This** **kind** **of** stability **is** **also** **called** resilience. **In** **that** **case**, climax communities **would** **be** **the** **most** **fragile** **and** **the** **least** **stable**, **since** **they** **can** **require** **hundreds** **of** **years** **to** **return** **to** **the** climax **state**.

**Even** **the** **kind** **of** stability defined **as** **simple** **lack** **of** **change** **is** **not** **always** **associated** **with** **maximum** diversity. **At** **least** **in** temperate **zones**, **maximum** diversity **is** **often** **found** **in** mid-successional **stages**, **not** **in** **the** climax community. **Once** **a** redwood **forest** **matures**, **for** **example**, **the** **kinds** **of** species **and** **the** **number** **of** individuals **growing** **on** **the** **forest** **floor** **are** **reduced**. **In** **general**, diversity, **by** **itself**, **does** **not** ensure stability. Mathematical **models** **of** ecosystems likewise **suggest** **that** diversity **does** **not** **guarantee** ecosystem stability—**just** **the** **opposite**, **in** **fact**. **A** **more** complicated **system** **is**, **in** **general**, **more** **likely** **than** **a** **simple** **system** **to** **break** **down**. **A** **fifteen**-**speed** **racing** **bicycle** **is** **more** **likely** **to** **break** **down** **than** **a** **child**’s tricycle.

Ecologists **are** **especially** **interested** **to** **know** **what** factors **contribute** **to** **the** resilience **of** communities **because** climax communities **all** **over** **the** **world** **are** **being** severely **damaged** **or** **destroyed** **by** **human** **activities**. **The** destruction **caused** **by** **the** volcanic explosion **of** Mount St. Helens, **in** **the** northwestern **United** **States**, **for** **example**, **pales** **in** comparison **to** **the** destruction **caused** **by** **humans**. **We** **need** **to** **know** **what** **aspects** **of** **a** community **are** **most** **important** **to** **the** community’s resistance **to** destruction, **as** **well** **as** **its** recovery.

**Many** ecologists **now** **think** **that** **the** **relative** **long**-**term** stability **of** climax communities **comes** **not** **from** diversity **but** **from** **the** “patchiness” **of** **the** **environment**, an **environment** **that** varies **from** **place** **to** **place** **supports** **more** **kinds** **of** organisms **than** an **environment** **that** **is** **uniform**. **A** **local** **population** **that** **goes** extinct **is** quickly **replaced** **by** immigrants **from** an adjacent community. **Even** **if** **the** **new** **population** **is** **of** **a** **different** species, **it** **can** **approximately** **fill** **the** niche vacated **by** **the** extinct **population** **and** **keep** **the** **food** **web** intact.

count: 192

# Official 08-Passage 01 The Rise of Teotihuacán

**The** **city** **of** Teotihuacán, **which** **lay** **about** 50 kilometers **northeast** **of** **modern**-**day** **Mexico** **City**, **began** **its** **growth** **by** 200 –100 B.C. **At** **its** **height**, **between** **about** **A**.D. 150 **and** 700, **it** **probably** **had** **a** **population** **of** **more** **than** 125,000 **people** **and** **covered** **at** **least** 20 **square** kilometers. **It** **had** **over** 2,000 **apartment** **complexes**, **a** **great** **market**, **a** **large** **number** **of** industrial workshops, an administrative center, **a** **number** **of** massive **religious** edifices, **and** **a** **regular** grid **pattern** **of** **streets** **and** **buildings**. **Clearly**, **much** **planning** **and** **central** **control** **were** involved **in** **the** expansion **and** **ordering** **of** **this** **great** metropolis. Moreover, **the** **city** **had** economic **and** **perhaps** **religious** contacts **with** **most** **parts** **of** Mesoamerica (**modern** **Central** **America** **and** **Mexico**).

**How** **did** **this** tremendous **development** **take** **place**, **and** **why** **did** **it** **happen** **in** **the** Teotihuacán **Valley**? **Among** **the** **main** factors **are** Teotihuacán’s geographic location **on** **a** **natural** **trade** route **to** **the** **south** **and** **east** **of** **the** **Valley** **of** **Mexico**, **the** obsidian resources **in** **the** Teotihuacán **Valley** **itself**, **and** **the** **valley**’s **potential** **for** extensive **irrigation**. **The** **exact** **role** **of** **other** factors **is** **much** **more** **difficult** **to** pinpoint—**for** instance, Teotihuacán’s **religious** **significance** **as** **a** shrine, **the** historical **situation** **in** **and** **around** **the** **Valley** **of** **Mexico** **toward** **the** **end** **of** **the** **first** millennium B.C., **the** ingenuity **and** foresightedness **of** Teotihuacán’s elite, **and**, finally, **the** impact **of** **natural** **disasters**, **such** **as** **the** volcanic eruptions **of** **the** **late** **first** millennium B.C.

**This** **last** factor **is** **at** **least** circumstantially implicated **in** Teotihuacán’s **rise**. Prior **to** 200 B.C., **a** **number** **of** relatively **small** centers coexisted **in** **and** **near** **the** **Valley** **of** **Mexico**. **Around** **this** **time**, **the** largest **of** **these** centers, Cuicuilco, **was** seriously **affected** **by** **a** volcanic eruption, **with** **much** **of** **its** **agricultural** **land** **covered** **by** lava. **With** Cuicuilco eliminated **as** **a** **potential** rival, **any** **one** **of** **a** **number** **of** relatively **modest** **towns** **might** **have** emerged **as** **a** **leading** economic **and** **political** **power** **in** **Central** **Mexico**. **The** archaeological **evidence** **clearly** indicates, **though**, **that** Teotihuacán **was** **the** center **that** **did** **arise** **as** **the** predominant **force** **in** **the** **area** **by** **the** **first** **century** **A**.D.

**It** **seems** **likely** **that** Teotihuacán’s **natural** resources—**along** **with** **the** **city** elite’s **ability** **to** recognize **their** **potential**—**gave** **the** **city** **a** competitive **edge** **over** **its** neighbors. **The** **valley**, **like** **many** **other** **places** **in** **Mexican** **and** Guatemalan highlands, **was** **rich** **in** obsidian. **The** **hard** volcanic **stone** **was** **a** resource **that** **had** **been** **in** **great** **demand** **for** **many** **years**, **at** **least** **since** **the** **rise** **of** **the** Olmecs (**a** **people** **who** flourished **between** 1200 **and** 400 B.C.), **and** **it** apparently **had** **a** **secure** **market**. Moreover, **recent** **research** **on** obsidian **tools** **found** **at** Olmec sites **has** **shown** **that** **some** **of** **the** obsidian **obtained** **by** **the** Olmecs originated **near** Teotihuacán. Teotihuacán obsidian must **have** **been** recognized **as** **a** **valuable** commodity **for** **many** **centuries** **before** **the** **great** **city** **arose**.

**Long**-**distance** **trade** **in** obsidian **probably** **gave** **the** elite residents **of** Teotihuacán **access** **to** **a** **wide** **variety** **of** exotic **goods**, **as** **well** **as** **a** relatively prosperous **life**. **Such** **success** may **have** **attracted** immigrants **to** Teotihuacán. **In** **addition**, Teotihuacán’s elite may **have** consciously **attempted** **to** **attract** **new** inhabitants. **It** **is** **also** **probable** **that** **as** **early** **as** 200 B.C. Teotihuacán may **have** **achieved** **some** **religious** **significance** **and** **its** shrine (**or** shrines) may **have** **served** **as** an additional **population** magnet. Finally, **the** **growing** **by** **increasing** **the** **number** **and** **size** **of** **irrigated** **fields**.

**The** **picture** **of** Teotihuacán **that** emerges **is** **a** **classic** **picture** **of** positive feedback **among** obsidian **mining** **and** **working**, **trade**, **population** **growth**, **irrigation**, **and** **religious** **tourism**. **The** thriving obsidian **operation**, **for** **example**, **would** necessitate **more** miners, additional manufacturers **of** obsidian **tools**, **and** additional traders **to** **carry** **the** **goods** **to** **new** **markets**. **All** **this** **led** **to** **increased** **wealth**, **which** **in** **turn** **would** **attract** **more** immigrants **to** Teotihuacán. **The** **growing** **power** **of** **the** elite, **who** **controlled** **the** economy, **would** **give** **them** **the** **means** **to** physically coerce **people** **to** **move** **to** Teotihuacán **and** **serve** **as** **additions** **to** **the** labor **force**. **More** **irrigation** **works** **would** **have** **to** **be** **built** **to** **feed** **the** **growing** **population**, **and** **this** **resulted** **in** **more** **power** **and** **wealth** **for** **the** elite.

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count: 191

# Official 42-Passage 02 Geographic Isolation of Species

Biologist Ernst Mayr defined **a** species **as** “an actually **or** potentially interbreeding **population** **that** **does** **not** interbreed **with** **other** **such** **populations** **when** **there** **is** opportunity **to** **do** **so**.” **A** **key** **event** **in** **the** **origin** **of** **many** species **is** **the** **separation** **of** **a** **population** **with** **its** gene **pool** （**all** **of** **the** genes **in** **a** **population** **at** **any** **one** **time**） **from** **other** **populations** **of** **the** **same** species, thereby **preventing** **population** interbreeding. **With** **its** gene **pool** isolated, **a** **separate** **population** **can** **follow** **its** **own** evolutionary **course**. **In** **the** formation **of** **many** species, **the** **initial** isolation **of** **a** **population** **seems** **to** **have** **been** **a** geographic **barrier**. **This** mode **of** evolving **new** species **is** **called** allopatric speciation.

**Many** factors **can** isolate **a** **population** geographically. **A** **mountain** **range** may emerge **and** **gradually** **split** **a** **population** **of** organisms **that** **can** inhabit **only** lowland **lakes**; **certain** **fish** **populations** **might** **become** isolated **in** **this** **way**. Similarly, **a** creeping glacier may **gradually** **divide** **a** **population**, **or** **a** **land** **bridge** **such** **as** **the** Isthmus **of** Panama may **form** **and** **separate** **the** marine **life** **in** **the** **ocean** **waters** **on** **either** **side**.

**How** formidable must **a** geographic **barrier** **be** **to** **keep** **populations** **apart**? **It** **depends** **on** **the** **ability** **of** **the** organisms **to** **move** **across** **barriers**. **Birds** **and** coyotes **can** **easily** **cross** **mountains** **and** **rivers**. **The** **passage** **of** **wind**-**blown** **tree** pollen **is** **also** **not** hindered **by** **such** **barriers**, **and** **the** **seeds** **of** **many** **plants** may **be** **carried** **back** **and** forth **on** **animals**. **In** contrast, **small** rodents may **find** **a** **deep** canyon **or** **a** **wide** **river** an effective **barrier**. **For** **example**, **the** **Grand** Canyon, **in** **the** southwestern **United** **States**, **separates** **the** **range** **of** **the** **white**-**tailed** antelope **squirrel** **from** **that** **of** **the** closely **related** Harris’ antelope **squirrel**. Smaller, **with** **a** shorter **tail** **that** **is** **white** underneath, **the** **white**-**tailed** antelope **squirrel** inhabits **deserts** **north** **of** **the** canyon **and** **west** **of** **the** Colorado **River** **in** **southern** California. Harris’ antelope **squirrel** **has** **a** **more** **limited** **range** **in** **deserts** **south** **of** **the** **Grand** Canyon.

Geographic isolation **creates** opportunities **for** **new** species **to** **develop**, **but** **it** **does** **not** necessarily **lead** **to** **new** species **because** speciation **occurs** **only** **when** **the** gene **pool** undergoes **enough** **changes** **to** establish reproductive **barriers** **between** **the** isolated **population** **and** **its** **parent** **population**. **The** likelihood **of** allopatric speciation **increases** **when** **a** **population** **is** **small** **as** **well** **as** isolated, **making** **it** **more** **likely** **than** **a** **large** **population** **to** **have** **its** gene **pool** **changed** substantially. **For** **example**, **in** **less** **than** **two** **million** **years**, **small** **populations** **of** stray **animals** **and** **plants** **from** **the** **South** **American** **mainland** **that** **managed** **to** colonize **the** Galapagos **Islands** **gave** **rise** **to** **all** **the** species **that** **now** inhabit **the** **islands**.

**When** oceanic **islands** **are** **far** **enough** **apart** **to** **permit** **populations** **to** evolve **in** isolation, **but** **close** **enough** **to** **allow** occasional dispersions **to** **occur**, **they** **are** effectively outdoor laboratories **of** **evolution**. **The** Galapagos **island** **chain** **is** **one** **of** **the** **world**’s greatest showcases **of** **evolution**. **Each** **island** **was** **born** **from** underwater **volcanoes** **and** **was** **gradually** **covered** **by** organisms derived **from** strays **that** **rode** **the** **ocean** currents **and** **winds** **from** **other** **islands** **and** **continents**. Organisms **can** **also** **be** **carried** **to** **islands** **by** **other** organisms, **such** **as** **sea** **birds** **that** **travel** **long** **distances** **with** **seeds** clinging **to** **their** **feathers**.

**The** species **on** **the** Galapagos **Islands** **today**, **most** **of** **which** **occur** **nowhere** **else**, descended **from** organisms **that** **floated**, **flew**, **or** **were** **blown** **over** **the** **sea** **from** **the** **South** **American** **mainland**. **For** instance, **the** Galapagos **island** **chain** **has** **a** **total** **of** **thirteen** species **of** closely **related** **birds** **called** Galapagos finches. **These** **birds** **have** **many** similarities **but** **differ** **in** **their** **feeding** **habits** **and** **their** beak **type**, **which** **is** correlated **with** **what** **they** **eat**. **Accumulated** **evidence** indicates **that** **all** **thirteen** finch species evolved **from** **a** **single** **small** **population** **of** ancestral **birds** **that** colonized **one** **of** **the** **islands**. Completely isolated **on** **the** **island** after migrating **from** **the** **mainland**, **the** founder **population** may **have** undergone significant **changes** **in** **its** gene **pool** **and** **become** **a** **new** species. **Later**, **a** **few** individuals **of** **this** **new** species may **have** **been** **blown** **by** **storms** **to** **a** neighboring **island**. Isolated **on** **this** **second** **island**, **the** **second** founder **population** **could** **have** evolved **into** **a** **second** **new** species, **which** **could** **later** recolonize **the** **island** **from** **which** **its** **founding** **population** emigrated. **Today** **each** Galapagos **island** **has** multiple species **of** finches, **with** **as** **many** **as** **ten** **on** **some** **islands**.

count: 190

# Official 07-Passage 01 The Geologic History of the Mediterranean

**In** 1970 geologists Kenneth J. Hsu **and** William B. **F**. Ryan **were** **collecting** **research** **data** **while** **aboard** **the** oceanographic **research** vessel Glomar Challenger. An objective **of** **this** **particular** cruise **was** **to** investigate **the** **floor** **of** **the** Mediterranean **and** **to** resolve **questions** **about** **its** geologic **history**. **One** **question** **was** **related** **to** **evidence** **that** **the** invertebrate fauna (**animals** **without** spines) **of** **the** Mediterranean **had** **changed** abruptly **about** 6 **million** **years** **ago**. **Most** **of** **the** older organisms **were** **nearly** **wiped** **out**, **although** **a** **few** hardy species **survived**. **A** **few** **managed** **to** migrate **into** **the** **Atlantic**. Somewhat **later**, **the** migrants **returned**, **bringing** **new** species **with** **them**. **Why** **did** **the** **near** extinction **and** migrations **occur**?

**Another** **task** **for** **the** Glomar Challenger’s **scientists** **was** **to** **try** **to** **determine** **the** **origin** **of** **the** domelike **masses** **buried** **deep** **beneath** **the** Mediterranean seafloor. **These** structures **had** **been** detected **years** earlier **by** echo-**sounding** **instruments**, **but** **they** **had** **never** **been** penetrated **in** **the** **course** **of** **drilling**. **Were** **they** **salt** domes **such** **as** **are** **common** **along** **the** **United** **States** Gulf **Coast**, **and** **if** **so**, **why** **should** **there** **have** **been** **so** **much** **solid** crystalline **salt** **beneath** **the** **floor** **of** **the** Mediterranean?

**With** **questions** **such** **as** **these** **clearly** **before** **them**, **the** **scientists** **aboard** **the** Glomar Challenger proceeded **to** **the** Mediterranean **to** **search** **for** **the** **answers**. **On** **August** 23, 1970, **they** **recovered** **a** sample. **The** sample **consisted** **of** pebbles **of** hardened sediment **that** **had** **once** **been** **soft**, **deep**-**sea** **mud**, **as** **well** **as** granules **of** gypsum [1] **and** fragments **of** volcanic **rock**. **Not** **a** **single** pebble **was** **found** **that** **might** **have** indicated **that** **the** pebbles **came** **from** **the** **nearby** **continent**. **In** **the** **days** **following**, samples **of** **solid** gypsum **were** repeatedly **brought** **on** deck **as** **drilling** **operations** penetrated **the** seafloor. Furthermore, **the** gypsum **was** **found** **to** **possess** peculiarities **of** **composition** **and** structure **that** **suggested** **it** **had** **formed** **on** **desert** **flats**. Sediment **above** **and** **below** **the** gypsum layer **contained** **tiny** marine fossils, indicating **open**-**ocean** **conditions**. **As** **they** **drilled** **into** **the** **central** **and** deepest **part** **of** **the** Mediterranean **basin**, **the** **scientists** **took** **solid**, shiny, crystalline **salt** **from** **the** core barrel. Interbedded **with** **the** **salt** **were** **thin** layers **of** **what** **appeared** **to** **be** windblown silt.

**The** **time** **had** **come** **to** formulate **a** hypothesis. **The** investigators theorized **that** **about** 20 **million** **years** **ago**, **the** Mediterranean **was** **a** **broad** seaway **linked** **to** **the** **Atlantic** **by** **two** **narrow** **straits**. Crustal **movements** **closed** **the** **straits**, **and** **the** landlocked Mediterranean **began** **to** evaporate. **Increasing** salinity **caused** **by** **the** evaporation **resulted** **in** **the** extermination **of** **scores** **of** invertebrate species. **Only** **a** **few** organisms **especially** tolerant **of** **very** **salty** **conditions** **remained**. **As** evaporation **continued**, **the** **remaining** brine (**salt** **water**) **became** **so** dense **that** **the** calcium sulfate **of** **the** **hard** layer **was** precipitated. **In** **the** **central** deeper **part** **of** **the** **basin**, **the** **last** **of** **the** brine evaporated **to** precipitate **more** soluble sodium chloride (**salt**). **Later**, **under** **the** **weight** **of** overlying sediments, **this** **salt** **flowed** plastically **upward** **to** **form** **salt** domes. **Before** **this** **happened**, **however**, **the** Mediterranean **was** **a** **vast** **desert** 3,000 meters **deep**. **Then**, **about** 5.5 **million** **years** **ago** **came** **the** deluge. **As** **a** **result** **of** crustal **adjustments** **and** **faulting**, **the** **Strait** **of** Gibraltar, **where** **the** Mediterranean **now** **connects** **to** **the** **Atlantic**, **opened**, **and** **water** cascaded spectacularly **back** **into** **the** Mediterranean. Turbulent **waters** **tore** **into** **the** hardened **salt** **flats**, **broke** **them** **up**, **and** **ground** **them** **into** **the** pebbles **observed** **in** **the** **first** sample **taken** **by** **the** Challenger. **As** **the** **basin** **was** refilled, **normal** marine organisms **returned**. **Soon** layers **of** oceanic ooze **began** **to** **accumulate** **above** **the** **old** **hard** layer.

**The** **salt** **and** gypsum, **the** faunal **changes**, **and** **the** **unusual** gravel **provided** **abundant** **evidence** **that** **the** Mediterranean **was** **once** **a** **desert**.

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 gypsum: **a** **mineral** **made** **of** calcium sulfate **and** **water**

count: 190

# Official 01-Passage 03 Timberline Vegetation on Mountains

**The** transition **from** **forest** **to** treeless tundra **on** **a** **mountain** slope **is** **often** **a** dramatic **one**. **Within** **a** **vertical** **distance** **of** **just** **a** **few** **tens** **of** meters, **trees** **disappear** **as** **a** **life**-**form** **and** **are** **replaced** **by** **low** shrubs, **herbs**, **and** **grasses**. **This** **rapid** **zone** **of** transition **is** **called** **the** **upper** timberline **or** **tree** **line**. **In** **many** semiarid **areas** **there** **is** **also** **a** lower timberline **where** **the** **forest** **passes** **into** steppe **or** **desert** **at** **its** lower **edge**, **usually** **because** **of** **a** **lack** **of** moisture.

**The** **upper** timberline, **like** **the** **snow** **line**, **is** highest **in** **the** tropics **and** lowest **in** **the** polar regions. **It** **ranges** **from** **sea** **level** **in** **the** polar regions **to** 4,500 meters **in** **the** **dry** subtropics **and** 3,500-4,500 meters **in** **the** moist tropics. Timberline **trees** **are** normally evergreens, **suggesting** **that** **these** **have** **some** **advantage** **over** deciduous **trees** (**those** **that** **lose** **their** **leaves**) **in** **the** **extreme** **environments** **of** **the** **upper** timberline. **There** **are** **some** **areas**, **however**, **where** broadleaf deciduous **trees** **form** **the** timberline. Species **of** birch, **for** **example**, may **occur** **at** **the** timberline **in** **parts** **of** **the** Himalayas.

**At** **the** **upper** timberline **the** **trees** **begin** **to** **become** **twisted** **and** deformed. **This** **is** particularly **true** **for** **trees** **in** **the** **middle** **and** **upper** latitudes, **which** **tend** **to** **attain** greater **heights** **on** ridges, whereas **in** **the** tropics **the** **trees** **reach** **their** greater **heights** **in** **the** **valleys**. **This** **is** **because** **middle**- **and** **upper**-latitude timberlines **are** strongly **influenced** **by** **the** duration **and** **depth** **of** **the** **snow** **cover**. **As** **the** **snow** **is** deeper **and** **lasts** longer **in** **the** **valleys**, **trees** **tend** **to** **attain** greater **heights** **on** **the** ridges, **even** **though** **they** **are** **more** **exposed** **to** **high**-velocity **winds** **and** **poor**, **thin** **soils** **there**. **In** **the** tropics, **the** **valleys** **appear** **to** **be** **more** favorable **because** **they** **are** **less** prone **to** **dry** **out**, **they** **have** **less** **frost**, **and** **they** **have** deeper **soils**.

**There** **is** **still** **no** universally **agreed**-**on** **explanation** **for** **why** **there** **should** **be** **such** **a** dramatic cessation **of** **tree** **growth** **at** **the** **upper** timberline. **Various** environmental factors may **play** **a** **role**. **Too** **much** **snow**, **for** **example**, **can** smother **trees**, **and** avalanches **and** **snow** creep **can** **damage** **or** **destroy** **them**. **Late**-**lying** **snow** **reduces** **the** effective **growing** **season** **to** **the** **point** **where** seedlings cannot establish **themselves**. **Wind** velocity **also** **increases** **with** **altitude** **and** may **cause** **serious** **stress** **for** **trees**, **as** **is** **made** **evident** **by** **the** deformed **shapes** **at** **high** **altitudes**. **Some** **scientists** **have** proposed **that** **the** presence **of** **increasing** **levels** **of** ultraviolet **light** **with** elevation may **play** **a** **role**, **while** browsing **and** grazing **animals** **like** **the** ibex may **be** **another** **contributing** factor. **Probably** **the** **most** **important** environmental factor **is** **temperature**, **for** **if** **the** **growing** **season** **is** **too** **short** **and** **temperatures** **are** **too** **low**, **tree** **shoots** **and** buds cannot **mature** sufficiently **to** **survive** **the** **winter** **months**.

**Above** **the** **tree** **line** **there** **is** **a** **zone** **that** **is** generally **called** alpine tundra. **Immediately** adjacent **to** **the** timberline, **the** tundra **consists** **of** **a** **fairly** **complete** **cover** **of** **low**-**lying** shrubs, **herbs**, **and** **grasses**, **while** higher **up** **the** **number** **and** diversity **of** species **decrease** **until** **there** **is** **much** **bare** **ground** **with** occasional mosses **and** lichens **and** **some** prostrate **cushion** **plants**. **Some** **plants** **can** **even** **survive** **in** favorable microhabitats **above** **the** **snow** **line**. **The** highest **plants** **in** **the** **world** **occur** **at** **around** 6,100 meters **on** Makalu **in** **the** Himalayas. **At** **this** **great** **height**, **rocks**, **warmed** **by** **the** **sun**, melt **small** snowdrifts.

**The** **most** **striking** **characteristic** **of** **the** **plants** **of** **the** alpine **zone** **is** **their** **low** **growth** **form**. **This** enables **them** **to** **avoid** **the** **worst** rigors **of** **high** **winds** **and** **permits** **them** **to** **make** **use** **of** **the** higher **temperatures** **immediately** adjacent **to** **the** **ground** **surface**. **In** an **area** **where** **low** **temperatures** **are** **limiting** **to** **life**, **the** **importance** **of** **the** additional **heat** **near** **the** **surface** **is** crucial. **The** **low** **growth** **form** **can** **also** **permit** **the** **plants** **to** **take** **advantage** **of** **the** insulation **provided** **by** **a** **winter** **snow** **cover**. **In** **the** equatorial **mountains** **the** **low** **growth** **form** **is** **less** prevalent.

count: 190

# Official 12-Passage 01 Which Hand Did They Use?

**We** **all** **know** **that** **many** **more** **people** **today** **are** **right-handed** **than** **left-handed**. **Can** **one** trace **this** **same** **pattern** **far** **back** **in** prehistory? **Much** **of** **the** **evidence** **about** **right**-**hand** versus **left**-**hand** dominance **comes** **from** stencils **and** **prints** **found** **in** **rock** **shelters** **in** **Australia** **and** elsewhere, **and** **in** **many** **Ice** **Age** **caves** **in** **France**, **Spain**, **and** Tasmania. **When** **a** **left** **hand** **has** **been** stenciled, **this** implies **that** **the** **artist** **was** **right-handed**, **and** **vice** versa. **Even** **though** **the** **paint** **was** **often** **sprayed** **on** **by** **mouth**, **one** **can** **assume** **that** **the** dominant **hand** **assisted** **in** **the** **operation**. **One** **also** **has** **to** **make** **the** **assumption** **that** **hands** **were** stenciled palm **downward**—**a** **left** **hand** stenciled palm **upward** **might** **of** **course** **look** **as** **if** **it** **were** **a** **right** **hand**. **Of** 158 stencils **in** **the** **French** **cave** **of** Gargas, 136 **have** **been** identified **as** **left**, **and** **only** 22 **as** **right**; **right**-handedness **was** **therefore** **heavily** predominant.

**Cave** **art** furnishes **other** **types** **of** **evidence** **of** **this** **phenomenon**. **Most** engravings, **for** **example**, **are** **best** **lit** **from** **the** **left**, **as** befits **the** **work** **of** **right-handed** **artists**, **who** generally **prefer** **to** **have** **the** **light** source **on** **the** **left** **so** **that** **the** **shadow** **of** **their** **hand** **does** **not** **fall** **on** **the** **tip** **of** **the** engraving **tool** **or** **brush**. **In** **the** **few** **cases** **where** an **Ice** **Age** **figure** **is** depicted **holding** **something**, **it** **is** mostly, **though** **not** **always**, **in** **the** **right** **hand**.

Clues **to** **right**-handedness **can** **also** **be** **found** **by** **other** **methods**. **Right**-handers **tend** **to** **have** longer, stronger, **and** **more** muscular **bones** **on** **the** **right** **side**, **and** Marcellin Boule **as** **long** **ago** **as** 1911 **noted** **the** La Chapelle-aux-Saints Neanderthal skeleton **had** **a** **right** **upper** **arm** **bone** **that** **was** noticeably stronger **than** **the** **left**. **Similar** observations **have** **been** **made** **on** **other** Neanderthal skeletons **such** **as** La Ferrassie **I** **and** Neanderthal **itself**.

Fractures **and** **other** **cut** **marks** **are** **another** source **of** **evidence**. **Right-handed** **soldiers** **tend** **to** **be** **wounded** **on** **the** **left**. **The** skeleton **of** **a** 40- **or** 50-**year**-**old** Nabatean warrior, **buried** 2,000 **years** **ago** **in** **the** Negev **Desert**, Israel, **had** multiple healed fractures **to** **the** skull, **the** **left** **arm**, **and** **the** ribs.

**Tools** **themselves** **can** **be** revealing. **Long**-**handed** Neolithic **spoons** **of** yew **wood** **preserved** **in** Alpine **villages** **dating** **to** 3000 B.C. **have** **survived**; **the** **signs** **of** rubbing **on** **their** **left** **side** indicate **that** **their** **users** **were** **right-handed**. **The** **late** **Ice** **Age** **rope** **found** **in** **the** **French** **cave** **of** Lascaux **consists** **of** fibers spiraling **to** **the** **right**, **and** **was** **therefore** tressed **by** **a** **right**-hander.

Occasionally **one** **can** **determine** **whether** **stone** **tools** **were** **used** **in** **the** **right** **hand** **or** **the** **left**, **and** **it** **is** **even** **possible** **to** **assess** **how** **far** **back** **this** feature **can** **be** traced. **In** **stone** **tool** **making** **experiments**, Nick Toth, **a** **right**-hander, **held** **the** core (**the** **stone** **that** **would** **become** **the** **tool**) **in** **his** **left** **hand** **and** **the** **hammer** **stone** **in** **his** **right**. **As** **the** **tool** **was** **made**, **the** core **was** rotated clockwise, **and** **the** flakes, **removed** **in** sequence, **had** **a** **little** crescent **of** cortex (**the** core’s **outer** **surface**) **on** **the** **side**. Toth’s knapping **produced** 56 **percent** flakes **with** **the** cortex **on** **the** **right**, **and** 44 **percent** **left**-oriented flakes. **A** **left-handed** toolmaker **would** **produce** **the** **opposite** **pattern**. Toth **has** **applied** **these** **criteria** **to** **the** similarly **made** pebble **tools** **from** **a** **number** **of** **early** sites (**before** 1.5 **million** **years**) **at** Koobi Fora, Kenya, **probably** **made** **by** Homo habilis. **At** **seven** sites **he** **found** **that** 57 **percent** **of** **the** flakes **were** **right**-oriented, **and** 43 **percent** **left**, **a** **pattern** **almost** identical **to** **that** **produced** **today**.

**About** 90 **percent** **of** **modern** **humans** **are** **right-handed**: **we** **are** **the** **only** mammal **with** **a** preferential **use** **of** **one** **hand**. **The** **part** **of** **the** **brain** responsible **for** **fine** **control** **and** **movement** **is** located **in** **the** **left** cerebral hemisphere, **and** **the** findings **above** **suggest** **that** **the** **human** **brain** **was** **already** asymmetrical **in** **its** structure **and** **function** **not** **long** after 2 **million** **years** **ago**. **Among** Neanderthalers **of** 70,000 - 35,000 **years** **ago**, Marcellin Boule **noted** **that** **the** La Chapelle-aux-Saints individual **had** **a** **left** hemisphere slightly bigger **than** **the** **right**, **and** **the** **same** **was** **found** **for** **brains** **of** specimens **from** Neanderthal, Gibraltar, **and** La Quina.

count: 189

# Official 36-Passage 01 Soil Formation

**Living** organisms **play** an essential **role** **in** **soil** formation. **The** numerous **plants** **and** **animals** **living** **in** **the** **soil** release **minerals** **from** **the** **parent** **material** **from** **which** **soil** **is** **formed**, **supply** organic **matter**, **aid** **in** **the** translocation (**movement**) **and** aeration **of** **the** **soil**, **and** **help** **protect** **the** **soil** **from** erosion. **The** **types** **of** organisms **growing** **or** **living** **in** **the** **soil** greatly **influence** **the** **soil**’s **physical** **and** **chemical** **characteristics**. **In** **fact**, **for** **mature** **soils** **in** **many** **parts** **of** **the** **world**, **the** predominant **type** **of** **natural** vegetation **is** **considered** **the** **most** **important** **direct** **influence** **on** **soil** **characteristics**. **For** **this** **reason**, **a** **soil** **scientist** **can** **tell** **a** **great** **deal** **about** **the** attributes **of** **the** **soil** **in** **any** **given** **area** **simply** **from** **knowing** **what** **kind** **of** flora **the** **soil** **supports**. **Thus** **prairies** **and** tundra regions, **which** **have** **characteristic** vegetations, **also** **have** **characteristic** **soils**.

**The** **quantity** **and** **total** **weight** **of** **soil** flora generally exceed **that** **of** **soil** fauna. **By** **far** **the** **most** numerous **and** smallest **of** **the** **plants** **living** **in** **soil** **are** **bacteria**. **Under** favorable **conditions**, **a** **million** **or** **more** **of** **these** **tiny**, **single**-**celled** **plants** **can** inhabit **each** **cubic** centimeter **of** **soil**. **It** **is** **the** **bacteria**, **more** **than** **any** **other** organisms, **that** enable **rock** **or** **other** **parent** **material** **to** undergo **the** gradual transformation **to** **soil**. **Some** **bacteria** **produce** organic **acids** **that** directly **attack** **parent** **material**, **breaking** **it** **down** **and** releasing **plant** nutrients. **Others** decompose organic **litter** (debris) **to** **form** humus (nutrient-**rich** organic **matter**). **A** **third** **group** **of** **bacteria** inhabits **the** **root** **systems** **of** **plants** **called** legumes. **These** **include** **many** **important** **agricultural** **crops**, **such** **as** alfalfa, clover, soybeans, **peas**, **and** peanuts. **The** **bacteria** **that** legumes **host** **within** **their** **root** nodules (**small** swellings **on** **the** **root**) **change** nitrogen **gas** **from** **the** **atmosphere** **into** nitrogen compounds **that** **plants** **are** **able** **to** metabolize, **a** **process**, **known** **as** nitrogen fixation, **that** **makes** **the** **soil** **more** fertile. **Other** microscopic **plants** **also** **are** **important** **in** **soil** **development**. **For** **example**, **in** highly acidic **soils** **where** **few** **bacteria** **can** **survive**, fungi frequently **become** **the** **chief** decomposers **of** organic **matter**.

**More** **complex** **forms** **of** vegetation **play** **several** **vital** **roles** **with** **respect** **to** **the** **soil**. **Trees**, **grass**, **and** **other** **large** **plants** **supply** **the** bulk **of** **the** **soil**’s humus. **The** **minerals** released **as** **these** **plants** decompose **on** **the** **surface** constitute an **important** nutrient source **for** **succeeding** **generations** **of** **plants** **as** **well** **as** **for** **other** **soil** organisms. **In** **addition**, **trees** **can** extend **their** **roots** **deep** **within** **the** **soil** **and** **bring** **up** nutrients **from** **far** **below** **the** **surface**. **These** nutrients **eventually** enrich **the** **surface** **soil** **when** **the** **tree** **drops** **its** **leaves** **or** **when** **it** **dies** **and** decomposes. Finally, **trees** **perform** **the** **vital** **function** **of** **slowing** **water** runoff **and** **holding** **the** **soil** **in** **place** **with** **their** **root** **systems**, **thus** combating erosion. **The** **increased** erosion **that** **often** **accompanies** **agricultural** **use** **of** sloping **land** **is** principally **caused** **by** **the** removal **of** **its** protective **cover** **of** **natural** vegetation.

**Animals** **also** **influence** **soil** **composition**. **The** faunal counterparts **of** **bacteria** **are** protozoa. **These** **single**-**celled** organisms **are** **the** **most** numerous **representatives** **of** **the** **animal** **kingdom**, **and**, **like** **bacteria**, **a** **million** **or** **more** **can** **sometimes** inhabit **each** **cubic** centimeter **of** **soil**. Protozoa **feed** **on** organic **matter** **and** hasten **its** decomposition. **Among** **other** **soil**-dwelling **animals**, **the** earthworm **is** **probably** **the** **most** **important**. **Under** exceptionally favorable **conditions**, **up** **to** **a** **million** earthworms (**with** **a** **total** body **weight** exceeding 450 **kilograms**) may inhabit an **acre** **of** **soil**. Earthworms ingest **large** **quantities** **of** **soil**, chemically alter **it**, **and** excrete **it** **as** organic **matter** **called** **casts**. **The** **casts** **form** **a** **high**-**quality** **natural** fertilizer. **In** **addition**, earthworms **mix** **soil** **both** vertically **and** horizontally, **improving** aeration **and** drainage.

**Insects** **such** **as** **ants** **and** termites **also** **can** **be** exceedingly numerous **under** favorable climatic **and** **soil** **conditions**. **In** **addition**, mammals **such** **as** moles, **field** **mice**, gophers, **and** **prairie** **dogs** **sometimes** **are** **present** **in** sufficient **numbers** **to** **have** significant impact **on** **the** **soil**. **These** **animals** primarily **work** **the** **soil** mechanically. **As** **a** **result**, **the** **soil** **is** aerated, **broken** **up**, fertilized, **and** **brought** **to** **the** **surface**, hastening **soil** **development**.

count: 188

# Official 05-Passage 03 The Cambrian Explosion

**The** geologic timescale **is** **marked** **by** significant geologic **and** biological **events**, **including** **the** **origin** **of** **Earth** **about** 4.6 **billion** **years** **ago**, **the** **origin** **of** **life** **about** 3.5 **billion** **years** **ago**, **the** **origin** **of** eukaryotic **life**-**forms** (**living** **things** **that** **have** **cells** **with** **true** nuclei) **about** 1.5 **billion** **years** **ago**, **and** **the** **origin** **of** **animals** **about** 0.6 **billion** **years** **ago**. **The** **last** **event** **marks** **the** **beginning** **of** **the** Cambrian **period**. **Animals** originated relatively **late** **in** **the** **history** **of** **Earth**—**in** **only** **the** **last** 10 **percent** **of** **Earth**’s **history**. **During** **a** geologically **brief** 100-**million**-**year** **period**, **all** **modern** **animal** **groups** (**along** **with** **other** **animals** **that** **are** **now** extinct) evolved. **This** **rapid** **origin** **and** diversification **of** **animals** **is** **often** **referred** **to** **as** “**the** Cambrian explosion.”

**Scientists** **have** **asked** **important** **questions** **about** **this** explosion **for** **more** **than** **a** **century**. **Why** **did** **it** **occur** **so** **late** **in** **the** **history** **of** **Earth**? **The** **origin** **of** multicellular **forms** **of** **life** **seems** **a** relatively **simple** **step** **compared** **to** **the** **origin** **of** **life** **itself**. **Why** **does** **the** fossil **record** **not** **document** **the** series **of** evolutionary **changes** **during** **the** **evolution** **of** **animals**? **Why** **did** **animal** **life** evolve **so** quickly? Paleontologists **continue** **to** **search** **the** fossil **record** **for** **answers** **to** **these** **questions**.

**One** interpretation **regarding** **the** **absence** **of** fossils **during** **this** **important** 100-**million**-**year** **period** **is** **that** **early** **animals** **were** **soft** bodied **and** **simply** **did** **not** fossilize. Fossilization **of** **soft**-bodied **animals** **is** **less** **likely** **than** fossilization **of** **hard**-bodied **animals**, **but** **it** **does** **occur**. **Conditions** **that** **promote** fossilization **of** **soft**-bodied **animals** **include** **very** **rapid** **covering** **by** sediments **that** **create** an **environment** **that** **discourages** decomposition. **In** **fact**, fossil **beds** **containing** **soft**-bodied **animals** **have** **been** **known** **for** **many** **years**.

**The** Ediacara fossil formation, **which** **contains** **the** oldest **known** **animal** fossils, **consists** exclusively **of** **soft**-bodied **forms**. **Although** **named** after **a** site **in** **Australia**, **the** Ediacara formation **is** **worldwide** **in** distribution **and** **dates** **to** Precambrian **times**. **This** 700-**million**-**year**-**old** formation **gives** **few** clues **to** **the** **origins** **of** **modern** **animals**, **however**, **because** paleontologists **believe** **it** **represents** an evolutionary **experiment** **that** **failed**. **It** **contains** **no** **ancestors** **of** **modern** **animal** **groups**.

**A** slightly younger fossil formation **containing** **animal** **remains** **is** **the** Tommotian formation, **named** after **a** locale **in** **Russia**. **It** **dates** **to** **the** **very** **early** Cambrian **period**, **and** **it** **also** **contains** **only** **soft**-bodied **forms**. **At** **one** **time**, **the** **animals** **present** **in** **these** fossil **beds** **were** assigned **to** **various** **modern** **animal** **groups**, **but** **most** paleontologists **now** **agree** **that** **all** Tommotian fossils **represent** **unique** body **forms** **that** **arose** **in** **the** **early** Cambrian **period** **and** **disappeared** **before** **the** **end** **of** **the** **period**, **leaving** **no** descendants **in** **modern** **animal** **groups**.

**A** **third** fossil formation **containing** **both** **soft**-bodied **and** **hard**-bodied **animals** **provides** **evidence** **of** **the** **result** **of** **the** Cambrian explosion. **This** fossil formation, **called** **the** Burgess Shale, **is** **in** Yoho **National** **Park** **in** **the** **Canadian** Rocky **Mountains** **of** **British** Columbia. **Shortly** after **the** Cambrian explosion, **mud** **slides** rapidly **buried** **thousands** **of** marine **animals** **under** **conditions** **that** favored fossilization. **These** fossil **beds** **provide** **evidence** **of** **about** 32 **modern** **animal** **groups**, **plus** **about** 20 **other** **animal** body **forms** **that** **are** **so** **different** **from** **any** **modern** **animals** **that** **they** cannot **be** assigned **to** **any** **one** **of** **the** **modern** **groups**. **These** unassignable **animals** **include** **a** **large** **swimming** predator **called** Anomalocaris **and** **a** **soft**-bodied **animal** **called** Wiwaxia, **which** **ate** detritus **or** algae. **The** Burgess Shale formation **also** **has** fossils **of** **many** extinct **representatives** **of** **modern** **animal** **groups**. **For** **example**, **a** **well-known** Burgess Shale **animal** **called** Sidneyia **is** **a** **representative** **of** **a** previously **unknown** **group** **of** arthropods (**a** **category** **of** **animals** **that** **includes** **insects**, spiders, mites, **and** crabs).

Fossil formations **like** **the** Burgess Shale **show** **that** **evolution** cannot **always** **be** **thought** **of** **as** **a** **slow** progression. **The** Cambrian explosion involved **rapid** evolutionary diversification, **followed** **by** **the** extinction **of** **many** **unique** **animals**. **Why** **was** **this** **evolution** **so** **rapid**? **No** **one** **really** **knows**. **Many** zoologists **believe** **that** **it** **was** **because** **so** **many** ecological niches **were** **available** **with** virtually **no** **competition** **from** **existing** species. **Will** zoologists **ever** **know** **the** evolutionary sequences **in** **the** Cambrian explosion? **Perhaps** **another** **ancient** fossil **bed** **of** **soft**-bodied **animals** **from** 600-**million**-**year**-**old** **seas** **is** awaiting **discovery**.

count: 187

# Official 22-Passage 01 Spartina

Spartina alterniflora, **known** **as** cordgrass, **is** **a** deciduous, perennial **flowering** **plant** **native** **to** **the** **Atlantic** **coast** **and** **the** Gulf **Coast** **of** **the** **United** **States**. **It** **is** **the** dominant **native** species **of** **the** lower **salt** marshes **along** **these** **coasts**, **where** **it** **grows** **in** **the** intertidal **zone** (**the** **area** **covered** **by** **water** **some** **parts** **of** **the** **day** **and** **exposed** **others**).

**These** **natural** **salt** marshes **are** **among** **the** **most** productive habitats **in** **the** marine **environment**. Nutrient-**rich** **water** **is** **brought** **to** **the** wetlands **during** **each** **high** tide, **making** **a** **high** **rate** **of** **food** **production** **possible**. **As** **the** **seaweed** **and** marsh **grass** **leaves** **die**, **bacteria** **break** **down** **the** **plant** **material**, **and** **insects**, **small** shrimplike organisms, fiddler crabs, **and** marsh snails **eat** **the** decaying **plant** **tissue**, **digest** **it**, **and** excrete **wastes** **high** **in** nutrients. Numerous **insects** occupy **the** marsh, **feeding** **on** **living** **or** **dead** cordgrass **tissue**, **and** redwing blackbirds, **sparrows**, rodents, **rabbits**, **and** **deer** **feed** directly **on** **the** cordgrass. **Each** tidal **cycle** **carries** **plant** **material** **into** **the** **offshore** **water** **to** **be** **used** **by** **the** subtidal organisms.

Spartina **is** an exceedingly competitive **plant**. **It** **spreads** primarily **by** **underground** stems; colonies **form** **when** **pieces** **of** **the** **root** **system** **or** **whole** **plants** **float** **into** an **area** **and** **take** **root** **or** **when** **seeds** **float** **into** **a** **suitable** **area** **and** germinate. Spartina establishes **itself** **on** substrates **ranging** **from** **sand** **and** silt **to** gravel **and** cobble **and** **is** tolerant **of** salinities **ranging** **from** **that** **of** **near** freshwater (0.05 **percent**) **to** **that** **of** **salt** **water** (3.5 **percent**). **Because** **they** **lack** **oxygen**, marsh sediments **are** **high** **in** sulfides **that** **are** toxic **to** **most** **plants**. Spartina **has** **the** **ability** **to** **take** **up** sulfides **and** convert **them** **to** sulfate, **a** **form** **of** sulfur **that** **the** **plant** **can** **use**; **this** **ability** **makes** **it** easier **for** **the** **grass** **to** colonize marsh **environments**. **Another** adaptive **advantage** **is** Spartina’s **ability** **to** **use** **carbon** **dioxide** **more** efficiently **than** **most** **other** **plants**.

**These** **characteristics** **make** Spartina **a** **valuable** **component** **of** **the** estuaries **where** **it** **occurs** naturally. **The** **plant** **functions** **as** **a** stabilizer **and** **a** sediment **trap** **and** **as** **a** **nursery** **area** **for** estuarine **fish** **and** shellfish. **Once** established, **a** **stand** **of** Spartina **begins** **to** **trap** sediment, **changing** **the** substrate elevation, **and** **eventually** **the** **stand** evolves **into** **a** **high** marsh **system** **where** Spartina **is** **gradually** displaced **by** higher-elevation, brackish-**water** species. **As** elevation **increases**, **narrow**, **deep** **channels** **of** **water** **form** **throughout** **the** marsh. **Along** **the** **east** **coast** Spartina **is** **considered** **valuable** **for** **its** **ability** **to** **prevent** erosion **and** marshland deterioration; **it** **is** **also** **used** **for** coastal restoration **projects** **and** **the** creation **of** **new** wetland sites.

Spartina **was** **transported** **to** Washington **State** **in** **packing** **materials** **for** oysters transplanted **from** **the** **east** **coast** **in** 1894. **Leaving** **its** **insect** predators **behind**, **the** cordgrass **has** **been** **spreading** slowly **and** steadily **along** Washington’s tidal estuaries **on** **the** **west** **coast**, **crowding** **out** **the** **native** **plants** **and** drastically altering **the** landscape **by** **trapping** sediment. Spartina modifies tidal mudflats, **turning** **them** **into** **high** marshes inhospitable **to** **the** **many** **fish** **and** waterfowl **that** **depend** **on** **the** mudflats. **It** **is** **already** hampering **the** oyster **harvest** **and** **the** Dungeness crab fishery, **and** **it** interferes **with** **the** recreational **use** **of** **beaches** **and** waterfronts. Spartina **has** **been** transplanted **to** **England** **and** **to** **New Zealand** Zealand **for** **land** reclamation **and** shoreline stabilization. **In** **New Zealand** Zealand **the** **plant** **has** **spread** rapidly, **changing** mudflats **with** marshy fringes **to** extensive **salt** meadows **and** **reducing** **the** **number** **and** **kinds** **of** **birds** **and** **animals** **that** **use** **the** marsh.

**Efforts** **to** **control** Spartina **outside** **its** **natural** **environment** **have** **included** **burning**, **flooding**, shadingplants **with** **black** canvas **or** **plastic**, smothering **the** **plants** **with** dredged **materials** **or** **clay**, **applying** herbicide, **and** mowing repeatedly. **Little** **success** **has** **been** **reported** **in** **New Zealand** Zealand **and** **England**; Washington **State**’s management program **has** **tried** **many** **of** **these** **methods** **and** **is** presently **using** **the** herbicide glyphosphate **to** **control** **its** **spread**. **Work** **has** **begun** **to** **determine** **the** feasibility **of** **using** **insects** **as** biological **controls**, **but** effective biological **controls** **are** **considered** **years** **away**. **Even** **with** **a** massive **effort**, **it** **is** doubtful **that** **complete** eradication **of** Spartina **from** nonnative habitats **is** **possible**, **for** **it** **has** **become** an integral **part** **of** **these** shorelines **and** estuaries **during** **the** **last** 100 **to** 200 **years**.

count: 187

# Official 38-Passage 01 Microscopes

**Before** **microscopes** **were** **first** **used** **in** **the** seventeenth **century**, **no** **one** **knew** **that** **living** organisms **were** composed **of** **cells**. **The** **first** **microscopes** **were** **light** **microscopes**, **which** **work** **by** **passing** visible **light** **through** **a** specimen. **Glass** lenses **in** **the** **microscope** **bend** **the** **light** **to** magnify **the** image **of** **the** specimen **and** **project** **the** image **into** **the** **viewer**’s **eye** **or** **onto** photographic **film**. **Light** **microscopes** **can** magnify **objects** **up** **to** 1,000 **times** **without** **causing** blurriness.

Magnification, **the** **increase** **in** **the** **apparent** **size** **of** an **object**, **is** **one** **important** factor **in** microscopy. **Also** **important** **is** resolving **power**, **a** **measure** **of** **the** clarity **of** an image. Resolving **power** **is** **the** **ability** **of** an optical **instrument** **to** **show** **two** **objects** **as** **separate**. **For** **example**, **what** **looks** **to** **the** unaided **eye** **like** **a** **single** **star** **in** **the** **sky** may **be** resolved **as** **two** **stars** **with** **the** **help** **of** **a** **telescope**. **Any** optical device **is** **limited** **by** **its** resolving **power**. **The** **light** **microscope** cannot resolve detail finer **than** 0.2 micrometers, **about** **the** **size** **of** **the** smallest **bacterium**; consequently, **no** **matter** **how** **many** **times** **its** image **of** **such** **a** **bacterium** **is** magnified, **the** **light** **microscope** cannot **show** **the** details **of** **the** **cell**’s internal structure.

**From** **the** **year** 1665, **when** **English** microscopist Robert Hooke **discovered** **cells**, **until** **the** **middle** **of** **the** **twentieth** **century**, biologists **had** **only** **light** **microscopes** **for** **viewing** **cells**. **But** **they** **discovered** **a** **great** **deal**, **including** **the** **cells** composing **animal** **and** **plant** **tissues**, microscopic organisms, **and** **some** **of** **the** structures **within** **cells**. **By** **the** mid-1800s, **these** **discoveries** **led** **to** **the** **cell** **theory**, **which** **states** **that** **all** **living** **things** **are** composed **of** **cells** **and** **that** **all** **cells** **come** **from** **other** **cells**.

**Our** **knowledge** **of** **cell** structure **took** **a** giant leap **forward** **as** biologists **began** **using** **the** electron **microscope** **in** **the** 1950s. **Instead** **of** **light**, **the** electron **microscope** **uses** **a** **beam** **of** electrons **and** **has** **a** **much** higher resolving **power** **than** **the** **light** **microscope**. **In** **fact**, **the** **most** **powerful** **modern** electron **microscopes** **can** **distinguish** **objects** **as** **small** **as** 0.2 nanometers, **a** thousandfold improvement **over** **the** **light** **microscope**. **The** **period** **at** **the** **end** **of** **this** **sentence** **is** **about** **a** **million** **times** bigger **than** an **object** 0.2 nanometers **in** diameter, **which** **is** **the** **size** **of** **a** **large** **atom**. **Only** **under** **special** **conditions** **can** electron **microscopes** detect individual **atoms**. **However**, **cells**, cellular organelles, **and** **even** molecules **like** DNA **and** protein **are** **much** larger **than** **single** **atoms**.

Biologists **use** **the** **scanning** electron **microscope** **to** **study** **the** detailed **architecture** **of** **cell** **surfaces**. **It** **uses** an electron **beam** **to** **scan** **the** **surface** **of** **a** **cell** **or** **group** **of** **cells** **that** **have** **been** **coated** **with** **metal**. **The** **metal** **stops** **the** **beam** **from** **going** **through** **the** **cells**. **When** **the** **metal** **is** **hit** **by** **the** **beam**, **it** emits electrons. **The** electrons **are** **focused** **to** **form** an image **of** **the** **outside** **of** **the** **cells**. **The** **scanning** electron **microscope** **produces** images **that** **look** **three**-dimensional.

**The** transmission electron **microscope**, **on** **the** **other** **hand**, **is** **used** **to** **study** **the** details **of** internal **cell** structure. Specimens **are** **cut** **into** **extremely** **thin** **sections**, **and** **the** transmission electron **microscope** **aims** an electron **beam** **through** **a** **section**, **just** **as** **a** **light** **microscope** **aims** **a** **beam** **of** **light** **through** **a** specimen. **However**, **instead** **of** lenses **made** **of** **glass**, **the** transmission electron **microscope** **uses** electromagnets **as** lenses, **as** **do** **all** electron **microscopes**. **The** electromagnets **bend** **the** electron **beam** **to** magnify **and** **focus** an image **onto** **a** **viewing** **screen** **or** photographic **film**.

Electron **microscopes** **have** **truly** revolutionized **the** **study** **of** **cells** **and** **cell** organelles. Nonetheless, **they** **have** **not** **replaced** **the** **light** **microscope**. **One** **problem** **with** electron **microscopes** **is** **that** **they** cannot **be** **used** **to** **study** **living** specimens **because** **the** specimen must **be** **held** **in** **a** vacuum chamber; **that** **is**, **all** **the** **air** **and** **liquid** must **be** **removed**. **For** **a** biologist **studying** **a** **living** **process**, **such** **as** **the** whirling **movement** **of** **a** **bacterium**, **a** **light** **microscope** **equipped** **with** **a** **video** **camera** **might** **be** **better** **than** **either** **a** **scanning** electron **microscope** **or** **a** transmission electron **microscope**. **Thus**, **the** **light** **microscope** **remains** **a** **useful** **tool**, **especially** **for** **studying** **living** **cells**. **The** **size** **of** **a** **cell** **often** **determines** **the** **type** **of** **microscope** **a** biologist **uses** **to** **study** **it**.

count: 186

# Official 25-Passage 01 The Surface of Mars

**The** **surface** **of** Mars **shows** **a** **wide** **range** **of** geologic features, **including** **huge** **volcanoes**-**the** largest **known** **in** **the** **solar** **system**-**and** extensive impact cratering. **Three** **very** **large** **volcanoes** **are** **found** **on** **the** Tharsis bulge, an enormous geologic **area** **near** Mars’s equator. **Northwest** **of** Tharsis **is** **the** largest **volcano** **of** **all**: Olympus Mons, **with** **a** **height** **of** 25 kilometers **and** **measuring** **some** 700 kilometers **in** diameter **at** **its** **base**. **The** **three** **large** **volcanoes** **on** **the** Tharsis bulge **are** **a** **little** smaller-**a** “mere” 18 kilometers **high**.

**None** **of** **these** **volcanoes** **was** **formed** **as** **a** **result** **of** **collisions** **between** **plates** **of** **the** Martian crust-**there** **is** **no** **plate** motion **on** Mars. **Instead**, **they** **are** shield **volcanoes** — **volcanoes** **with** **broad**, sloping **slides** **formed** **by** molten **rock**. **All** **four** **show** distinctive lava **channels** **and** **other** **flow** features **similar** **to** **those** **found** **on** shield **volcanoes** **on** **Earth**. Images **of** **the** Martian **surface** reveal **many** **hundreds** **of** **volcanoes**. **Most** **of** **the** largest **volcanoes** **are** **associated** **with** **the** Tharsis bulge, **but** **many** smaller **ones** **are** **found** **in** **the** **northern** **plains**.

**The** **great** **height** **of** Martian **volcanoes** **is** **a** **direct** **consequence** **of** **the** **planet**’s **low** **surface** **gravity**. **As** lava **flows** **and** **spreads** **to** **form** **a** shield **volcano**, **the** **volcano**’s eventual **height** **depends** **on** **the** **new** **mountain**’s **ability** **to** **support** **its** **own** **weight**. **The** lower **the** **gravity**, **the** lesser **the** **weight** **and** **the** greater **the** **height** **of** **the** **mountain**. **It** **is** **no** **accident** **that** Maxwell Mons **on** Venus **and** **the** Hawaiian shield **volcanoes** **on** **Earth** **rise** **to** **about** **the** **same** **height** (**about** 10 kilometers) **above** **their** respective **bases**-**Earth** **and** Venus **have** **similar** **surface** **gravity**. Mars’s **surface** **gravity** **is** **only** 40 **percent** **that** **of** **Earth**, **so** **volcanoes** **rise** roughly2.5 **times** **as** **high**. **Are** **the** Martian shield **volcanoes** **still** **active**? **Scientists** **have** **no** **direct** **evidence** **for** **recent** **or** ongoing eruptions, **but** **if** **these** **volcanoes** **were** **active** **as** recently **as** 100 **million** **years** **ago** (an estimate **of** **the** **time** **of** **last** eruption **based** **on** **the** extent **of** impact cratering **on** **their** slopes), **some** **of** **them** may **still** **be** **at** **least** intermittently **active**. **Millions** **of** **years**, **though**, may **pass** **between** eruptions.

**Another** prominent feature **of** Mars’s **surface** **is** cratering. **The** Mariner spacecraft **found** **that** **the** **surface** **of** Mars, **as** **well** **as** **that** **of** **its** **two** **moons**, **is** pitted **with** impact craters **formed** **by** meteoroids **falling** **in** **from** **space**. **As** **on** **our** **Moon**, **the** smaller craters **are** **often** **filled** **with** **surface** **matter**-mostly **dust**-**confirming** **that** Mars **is** **a** **dry** **desert** **world**. **However**, Martian craters **get** **filled** **in** considerably faster **than** **their** lunar counterparts. **On** **the** **Moon**, **ancient** craters **less** **than** 100 meters **across** (**corresponding** **to** **depths** **of** **about** 20 meters) **have** **been** obliterated, primarily **by** meteoritic erosion. **On** Mars, **there** **are** relatively **few** craters **less** **than** 5 kilometers **in** diameter. **The** Martian **atmosphere** **is** an efficient erosive **agent**, **with** Martian **winds** **transporting** **dust** **from** **place** **to** **place** **and** erasing **surface** features **much** faster **than** meteoritic impacts **alone** **can** obliterate **them**.

**As** **on** **the** **Moon**, **the** extent **of** **large** impact cratering (i.e. craters **too** **big** **to** **have** **been** **filled** **in** **by** erosion **since** **they** **were** **formed**) **serves** **as** an **age** indicator **for** **the** Martian **surface**. **Age** estimates **ranging** **from** **four** **billion** **years** **for** Mars’s **southern** highlands **to** **a** **few** **hundred** **million** **years** **in** **the** youngest volcanic **areas** **were** **obtained** **in** **this** **way**.

**The** detailed **appearance** **of** Martian impact craters **provides** an **important** **piece** **of** **information** **about** **conditions** **just** **below** **the** **planet**’s **surface**. Martian craters **are** **surrounded** **by** ejecta (debris **formed** **as** **a** **result** **of** an impact) **that** **looks** **quite** **different** **from** **its** lunar counterparts. **A** comparison **of** **the** Copernicus crater **on** **the** **Moon** **with** **the** (**fairly** **typical**) crater Yuty **on** Mars demonstrates **the** **differences**. **The** ejecta **surrounding** **the** lunar crater **is** **just** **what** **one** **would** **expect** **from** an explosion ejecting **a** **large** volume **of** **dust**, **soil**, **and** boulders. **However**, **the** ejecta **on** Mars **gives** **the** distinct **impression** **of** **a** **liquid** **that** **has** splashed **or** **flowed** **out** **of** crater. Geologists **think** **that** **this** fluidized ejecta crater indicates **that** **a** layer **of** permafrost, **or** **water** **ice**, **lies** **just** **a** **few** meters **under** **the** **surface**. Explosive impacts **heated** **and** liquefied **the** **ice**, **resulting** **in** **the** fluid **appearance** **of** **the** ejecta.

count: 186

# Official 35-Passage 03 Earth’s Age

**One** **of** **the** **first** **recorded** observers **to** surmise **a** **long** **age** **for** **Earth** **was** **the** **Greek** historian Herodotus, **who** **lived** **from** **approximately** 480 B.C. **to** 425 B.C. **He** **observed** **that** **the** Nile **River** Delta **was** **in** **fact** **a** series **of** sediment **deposits** **built** **up** **in** successive **floods**. **By** **noting** **that** individual **floods** **deposit** **only** **thin** layers **of** sediment, **he** **was** **able** **to** **conclude** **that** **the** Nile Delta **had** **taken** **many** **thousands** **of** **years** **to** **build** **up**. **More** **important** **than** **the** **amount** **of** **time** Herodotus computed, **which** **turns** **out** **to** **be** trivial **compared** **with** **the** **age** **of** **Earth**, **was** **the** notion **that** **one** **could** estimate **ages** **of** geologic features **by** **determining** **rates** **of** **the** **processes** responsible **for** **such** features, **and** **then** **assuming** **the** **rates** **to** **be** roughly **constant** **over** **time**. **Similar** **applications** **of** **this** **concept** **were** **to** **be** **used** **again** **and** **again** **in** **later** **centuries** **to** estimate **the** **ages** **of** **rock** formations **and**, **in** **particular**, **of** layers **of** sediment **that** **had** compacted **and** cemented **to** **form** sedimentary **rocks**.

**It** **was** **not** **until** **the** seventeenth **century** **that** **attempts** **were** **made** **again** **to** **understand** clues **to** **Earth**’s **history** **through** **the** **rock** **record**. Nicolaus Steno (1638–1686) **was** **the** **first** **to** **work** **out** **principles** **of** **the** progressive **depositing** **of** sediment **in** Tuscany. **However**, James Hutton (1726–1797), **known** **as** **the** founder **of** **modern** geology, **was** **the** **first** **to** **have** **the** **important** insight **that** geologic **processes** **are** cyclic **in** **nature**. **Forces** **associated** **with** subterranean **heat** **cause** **land** **to** **be** uplifted **into** plateaus **and** **mountain** **ranges**. **The** **effects** **of** **wind** **and** **water** **then** **break** **down** **the** **masses** **of** uplifted **rock**, **producing** sediment **that** **is** **transported** **by** **water** **downward** **to** ultimately **form** layers **in** **lakes**, seashores, **or** **even** **oceans**. **Over** **time**, **the** layers **become** sedimentary **rock**. **These** **rocks** **are** **then** uplifted sometime **in** **the** **future** **to** **form** **new** **mountain** **ranges**, **which** exhibit **the** sedimentary layers (**and** **the** **remains** **of** **life** **within** **those** layers) **of** **the** earlier episodes **of** erosion **and** deposition.

Hutton’s **concept** **represented** **a** remarkable insight **because** **it** unified **many** individual **phenomena** **and** observations **into** **a** conceptual **picture** **of** **Earth**’s **history**. **With** **the** further **assumption** **that** **these** geologic **processes** **were** generally **no** **more** **or** **less** vigorous **than** **they** **are** **today**, Hutton’s examination **of** sedimentary layers **led** **him** **to** realize **that** **Earth**’s **history** must **be** enormous, **that** geologic **time** **is** an abyss **and** **human** **history** **a** speck **by** comparison.

After Hutton, geologists **tried** **to** **determine** **rates** **of** sedimentation **so** **as** **to** estimate **the** **age** **of** **Earth** **from** **the** **total** **length** **of** **the** sedimentary, **or** stratigraphic, **record**. **Typical** **numbers** **produced** **at** **the** **turn** **of** **the** **twentieth** **century** **were** 100 **million** **to** 400 **million** **years**. **These** underestimated **the** **actual** **age** **by** factors **of** 10 **to** 50 **because** **much** **of** **the** sedimentary **record** **is** **missing** **in** **various** locations **and** **because** **there** **is** **a** **long** **rock** sequence **that** **is** older **than** **half** **a** **billion** **years** **that** **is** **far** **less** **well** defined **in** **terms** **of** fossils **and** **less** **well** **preserved**.

**Various** **other** **techniques** **to** estimate **Earth**’s **age** **fell** **short**, **and** particularly noteworthy **in** **this** **regard** **were** flawed **determinations** **of** **the** **Sun**’s **age**. **It** **had** **been** recognized **by** **the** **German** philosopher Immanuel Kant (1724–1804) **that** **chemical** reactions **could** **not** **supply** **the** tremendous **amount** **of** energy **flowing** **from** **the** **Sun** **for** **more** **than** **about** **a** millennium. **Two** **physicists** **during** **the** nineteenth **century** **both** **came** **up** **with** **ages** **for** **the** **Sun** **based** **on** **the** **Sun**’s energy **coming** **from** gravitational contraction.**Under** **the** **force** **of** **gravity**, **the** compression **resulting** **from** **a** collapse **of** **the** **object** must release energy. **Ages** **for** **Earth** **were** derived **that** **were** **in** **the** **tens** **of** **millions** **of** **years**, **much** **less** **than** **the** geologic estimates **of** **the** **time**.

**It** **was** **the** **discovery** **of** radioactivity **at** **the** **end** **of** **the** nineteenth **century** **that** **opened** **the** **door** **to** **determining** **both** **the** **Sun**’s energy source **and** **the** **age** **of** **Earth**. **From** **the** **initial** **work** **came** **a** **suite** **of** **discoveries** **leading** **to** radioisotopic **dating**, **which** quickly **led** **to** **the** realization **that** **Earth** must **be** **billions** **of** **years** **old**, **and** **to** **the** **discovery** **of** **nuclear** fusion **as** an energy source capable **of** sustaining **the** **Sun**’s luminosity **for** **that** **amount** **of** **time**. **By** **the** 1960s, **both** **analysis** **of** meteorites **and** refinements **of** **solar** **evolution** **models** converged **on** an **age** **for** **the** **solar** **system**, **and** hence **for** **Earth**, **of** 4.5 **billion** **years**.

count: 186

# Official 43-Passage 02 The Origin of Petroleum

Petroleum **is** defined **as** **a** gaseous, **liquid**, **and** semisolid naturally **occurring** substance **that** **consists** chiefly **of** hydrocarbons (**chemical** compounds **of** **carbon** **and** **hydrogen**). Petroleum **is** **therefore** **a** **term** **that** **includes** **both** **oil** **and** **natural** **gas**. Petroleum **is** **nearly** **always** **found** **in** marine sedimentary **rocks**. **In** **the** **ocean**, microscopic phytoplankton (**tiny** **floating** **plants**) **and** **bacteria** (**simple**, **single**-**celled** organisms) **are** **the** principal sources **of** organic **matter** **that** **is** **trapped** **and** **buried** **in** sediment. **Most** **of** **the** organic **matter** **is** **buried** **in** **clay** **that** **is** slowly converted **to** **a** **fine**-**grained** sedimentary **rock** **known** **as** shale. **During** **this** conversion, organic compounds **are** **transformed** **to** **oil** **and** **natural** **gas**.

Sampling **on** **the** continental **shelves** **and** **along** **the** **base** **of** **the** continental slopes **has** **shown** **that** **fine** **muds** **beneath** **the** seafloor **contain** **up** **to** 8 **percent** organic **matter**. **Two** additional **kinds** **of** **evidence** **support** **the** hypothesis **that** petroleum **is** **a** **product** **of** **the** decomposition **of** organic **matter**: **oil** **possesses** optical properties **known** **only** **in** hydrocarbons derived **from** organic **matter**, **and** **oil** **contains** nitrogen **and** **certain** compounds **believed** **to** originate **only** **in** **living** **matter**. **A** **complex** sequence **of** **chemical** reactions **is** involved **in** converting **the** original **solid** organic **matter** **to** **oil** **and** **gas**, **and** additional **chemical** **changes** may **occur** **in** **the** **oil** **and** **gas** **even** after **they** **have** **formed**.

**It** **is** **now** **well** established **that** petroleum migrates **through** aquifers **and** **can** **become** **trapped** **in** reservoirs. Petroleum migration **is** analogous **to** groundwater migration. **When** **oil** **and** **gas** **are** **squeezed** **out** **of** **the** shale **in** **which** **they** originated **and** **enter** **a** body **of** sandstone **or** limestone **somewhere** **above**, **they** migrate readily **because** sandstones (**consisting** **of** quartz **grains**) **and** limestones (**consisting** **of** carbonate **minerals**) **are** **much** **more** permeable **than** **any** shale. **The** **force** **of** molecular **attraction** **between** **oil** **and** quartz **or** carbonate **minerals** **is** weaker **than** **that** **between** **water** **and** quartz **or** carbonate **minerals**. Hence, **because** **oil** **and** **water** **do** **not** **mix**, **water** **remains** **fastened** **to** **the** quartz **or** carbonate **grains**, **while** **oil** occupies **the** **central** **parts** **of** **the** larger **openings** **in** **the** porous sandstone **or** limestone. **Because** **oil** **is** lighter **than** **water**, **it** **tends** **to** glide **upward** **past** **the** carbonate- **and** quartz-**held** **water**. **In** **this** **way**, **oil** **becomes** segregated **from** **the** **water**; **when** **it** encounters **a** **trap**, **it** **can** **form** **a** **pool**.

**Most** **of** **the** petroleum **that** **forms** **in** sediments **does** **not** **find** **a** **suitable** **trap** **and** **eventually** **makes** **its** **way**, **along** **with** groundwater, **to** **the** **surface** **of** **the** **sea**. **It** **is** estimated **that** **no** **more** **than** 0.1 **percent** **of** **all** **the** organic **matter** originally **buried** **in** **a** sediment **is** **eventually** **trapped** **in** an **oil** **pool**. **It** **is** **not** **surprising**, **therefore**, **that** **the** highest ratio **of** **oil** **and** **gas** **pools** **to** volume **of** sediment **is** **found** **in** **rock** **no** older **than** 2.5 **million** **years**—**young** **enough** **so** **that** **little** **of** **the** petroleum **has** **leaked** **away**—**and** **that** **nearly** 60 **percent** **of** **all** **oil** **and** **gas** **discovered** **so** **far** **has** **been** **found** **in** strata **that** **formed** **in** **the** **last** 65 **million** **years**. **This** **does** **not** **mean** **that** older **rocks** **produced** **less** petroleum; **it** **simply** **means** **that** **oil** **in** older **rocks** **has** **had** **a** longer **time** **in** **which** **to** **leak** **away**.

**How** **much** **oil** **is** **there** **in** **the** **world**? **This** **is** an **extremely** **controversial** **question**. **Many** **billions** **of** barrels **of** **oil** **have** **already** **been** **pumped** **out** **of** **the** **ground**. **A** **lot** **of** additional **oil** **has** **been** located **by** **drilling** **but** **is** **still** **waiting** **to** **be** **pumped** **out**. **Possibly** **a** **great** **deal** **more** **oil** **remains** **to** **be** **found** **by** **drilling**. **Unlike** **coal**, **the** volume **of** **which** **can** **be** accurately estimated, **the** volume **of** undiscovered **oil** **can** **only** **be** **guessed** **at**. **Guesses** involve **the** **use** **of** **accumulated** **experience** **from** **a** **century** **of** **drilling**. **Knowing** **how** **much** **oil** **has** **been** **found** **in** an intensively **drilled** **area**, **such** **as** **eastern** Texas, **experts** **make** estimates **of** **probable** volumes **in** **other** regions **where** **rock** **types** **and** structures **are** **similar** **to** **those** **in** **eastern** Texas. **Using** **this** **approach** **and** **considering** **all** **the** sedimentary **basins** **of** **the** **world**, **experts** estimate **that** **somewhere** **between** 1,500 **and** 3,000 **billion** barrels **of** **oil** **will** **eventually** **be** **discovered**.

count: 185

# Official 47-Passage 02 Termite Ingenuity

    Termites, **social** **insects** **which** **live** **in** colonies **that**, **in** **some** species, **contain** 2 **million** individuals **or** **more**, **are** **often** incorrectly **referred** **to** **as** **white** **ants**. **But** **they** **are** **certainly** **not** **ants**. Termites, **unlike** **ants**, **have** gradual metamorphosis **with** **only** **three** **life** **stages**: **egg**, nymph, **and** **adult**. **Ants** **and** **the** **other** **social** **members** **of** **their** **order**, **certain** **bees** **and** wasps, **have** **complete** metamorphosis **in** **four** **life** **stages**: **egg**, larva, pupa, **and** **adult**. **The** **worker** **and** **soldier** castes **of** **social** **ants**, **bees**, **and** wasps **consist** **of** **only** **females**, **all** **daughters** **of** **a** **single** **queen** **that** **mated** **soon** after **she** **matured** **and** thereafter **never** **mated** **again**. **The** **worker** **and** **soldier** castes **of** termites **consist** **of** **both** **males** **and** **females**, **and** **the** **queen** **lives** permanently **with** **a** **male** consort.

**Since** termites **are** **small** **and** **soft**-bodied, **they** **easily** **become** desiccated **and** must **live** **in** moist **places** **with** **a** **high** **relative** humidity. **They** **do** **best** **when** **the** **relative** humidity **in** **their** **nest** **is** **above** 96 **percent** **and** **the** **temperature** **is** **fairly** **high**, an optimum **of** **about** 79°**F** **for** temperate **zone** species **and** **about** 86°**F** **for** tropical species. Subterranean termites, **the** destructive species **that** **occurs** commonly **throughout** **the** **eastern** **United** **States**, **attain** **these** **conditions** **by** **nesting** **in** moist **soil** **that** **is** **in** contact **with** **wood**, **their** **only** **food**. **The** **surrounding** **soil** **keeps** **the** **nest** moist **and** **tends** **to** **keep** **the** **temperature** **at** **a** **more** **or** **less** favorable **level**. **When** **it** **is** **cold** **in** **winter**, subterranean termites **move** **to** burrows **below** **the** **frost** **line**.

**Some** tropical termites **are** **more** ingenious **engineers**, **constructing** **huge** **above**-**ground** **nests** **with** **built**-**in** “**air** **conditioning**” **that** **keeps** **the** **nest** moist, **at** **a** **constant** **temperature**, **and** **well** **supplied** **with** **oxygen**. **Among** **the** **most** architecturally **advanced** **of** **these** termites **is** an **African** species,

**According to** Lüscher, **a** **medium**-**sized** **nest** **of**

**But** **how** **is** **this** **well**-insulated **nest** ventilated? **Its** **many** occupants **require** **over** 250 quarts **of** **oxygen** (**more** **than** 1,200 quarts **of** **air**) **per** **day**. **How** **can** **so** **much** **oxygen** diffuse **through** **the** **thick** **walls** **of** **the** mound? **Even** **the** pores **in** **the** **wall** **are** **filled** **with** **water**, **which** **almost** **stops** **the** diffusion **of** **gases**. **The** **answer** **lies** **in** **the** **construction** **of** **the** **nest**. **The** interior **consists** **of** **a** **large** **central** core **in** **which** **the** fungus **is** **grown**, **below** **it** **is** **a** “**cellar**” **of** **empty** **space**, **above** **it** **is** an “attic” **of** **empty** **space**, **and** **within** **the** ridges **on** **the** **outer** **wall** **of** **the** **nest**, **there** **are** **many** **small** tunnels **that** **connect** **the** **cellar** **and** **the** attic. **The** **warm** **air** **in** **the** fungus **gardens** **rises** **through** **the** **nest** **up** **to** **the** attic. **From** **the** attic, **the** **air** **passes** **into** **the** tunnels **in** **the** ridges **and** **flows** **back** **down** **to** **the** **cellar**. **Gases**, mainly **oxygen** **coming** **in** **and** **carbon** **dioxide** **going** **out**, **easily** diffuse **into** **or** **out** **of** **the** ridges, **since** **their** **walls** **are** **thin** **and** **their** **surface** **area** **is** **large** **because** **they** protrude **far** **out** **from** **the** **wall** **of** **the** mound. **Thus** **air** **that** **flows** **down** **into** **the** **cellar** **through** **the** ridges **is** relatively **rich** **in** **oxygen**, **and** **has** **lost** **much** **of** **its** **carbon** **dioxide**. **It** **supplies** **the** **nest**’s inhabitants **with** **fresh** **oxygen** **as** **it** **rises** **through** **the** fungus-**growing** **area** **back** **up** **to** **the** attic.

count: 183

# Official 41-Passage 03 Climate of Venus

**Earth** **has** **abundant** **water** **in** **its** **oceans** **but** **very** **little** **carbon** **dioxide** **in** **its** relatively **thin** **atmosphere**. **By** contrast, Venus **is** **very** **dry** **and** **its** **thick** **atmosphere** **is** mostly **carbon** **dioxide**. **The** original **atmospheres** **of** **both** Venus **and** **Earth** **were** derived **at** **least** **in** **part** **from** **gases** spewed forth, **or** outgassed, **by** **volcanoes**. **The** **gases** **that** emanate **from** **present**-**day** **volcanoes** **on** **Earth**, **such** **as** Mount Saint Helens, **are** predominantly **water** vapor, **carbon** **dioxide**, **and** sulfur **dioxide**. **These** **gases** **should** **therefore** **have** **been** **important** **parts** **of** **the** original **atmospheres** **of** **both** Venus **and** **Earth**. **Much** **of** **the** **water** **on** **both** **planets** **is** **also** **thought** **to** **have** **come** **from** impacts **from** comets, icy bodies **formed** **in** **the** **outer** **solar** **system**.

**In** **fact**, **water** **probably** **once** dominated **the** Venusian **atmosphere**. Venus **and** **Earth** **are** **similar** **in** **size** **and** **mass**, **so** Venusian **volcanoes** may **well** **have** outgassed **as** **much** **water** vapor **as** **on** **Earth**, **and** **both** **planets** **would** **have** **had** **about** **the** **same** **number** **of** comets **strike** **their** **surfaces**. **Studies** **of** **how** **stars** evolve **suggest** **that** **the** **early** **Sun** **was** **only** **about** 70 **percent** **as** luminous **as** **it** **is** **now**, **so** **the** **temperature** **in** Venus’ **early** **atmosphere** must **have** **been** **quite** **a** **bit** lower. **Thus** **water** vapor **would** **have** **been** **able** **to** liquefy **and** **form** **oceans** **on** Venus. **But** **if** **water** vapor **and** **carbon** **dioxide** **were** **once** **so** **common** **in** **the** **atmospheres** **of** **both** **Earth** **and** Venus, **what** **became** **of** **Earth**’s **carbon** **dioxide**? **And** **what** **happened** **to** **the** **water** **on** Venus?

**The** **answer** **to** **the** **first** **question** **is** **that** **carbon** **dioxide** **is** **still** **found** **in** abundance **on** **Earth**, **but** **now**, **instead** **of** **being** **in** **the** **form** **of** atmospheric **carbon** **dioxide**, **it** **is** **either** dissolved **in** **the** **oceans** **or** chemically **bound** **into** carbonate **rocks**, **such** **as** **the** limestone **and** **marble** **that** **formed** **in** **the** **oceans**. **If** **Earth** **became** **as** **hot** **as** Venus, **much** **of** **its** **carbon** **dioxide** **would** **be** **boiled** **out** **of** **the** **oceans** **and** **baked** **out** **of** **the** crust. **Our** **planet** **would** **soon** **develop** **a** **thick**, oppressive **carbon** **dioxide** **atmosphere** **much** **like** **that** **of** Venus.

**To** **answer** **the** **question** **about** Venus’ **lack** **of** **water**, **we** must **return** **to** **the** **early** **history** **of** **the** **planet**. **Just** **as** **on** **present**-**day** **Earth**, **the** **oceans** **of** Venus **limited** **the** **amount** **of** atmospheric **carbon** **dioxide** **by** dissolving **it** **in** **the** **oceans** **and** binding **it** **up** **in** carbonate **rocks**. **But** **being** closer **to** **the** **Sun** **than** **Earth** **is**, **enough** **of** **the** **liquid** **water** **on** Venus **would** **have** vaporized **to** **create** **a** **thick** **cover** **of** **water** vapor **clouds**. **Since** **water** vapor **is** **a** greenhouse **gas**, **this** humid **atmosphere**—**perhaps** denser **than** **Earth**’s **present**-**day** **atmosphere**, **but** **far** **less** dense **than** **the** **atmosphere** **that** envelops Venus **today**—**would** **have** efficiently **trapped** **heat** **from** **the** **Sun**. **At** **first**, **this** **would** **have** **had** **little** **effect** **on** **the** **oceans** **of** Venus. **Although** **the** **temperature** **would** **have** **climbed** **above** 100° C, **the** **boiling** **point** **of** **water** **at** **sea** **level** **on** **Earth**, **the** **added** atmospheric **pressure** **from** **water** vapor **would** **have** **kept** **the** **water** **in** Venus’ **oceans** **in** **the** **liquid** **state**.

**This** **hot** **and** humid **state** **of** **affairs** may **have** persisted **for** **several** **hundred** **million** **years**. **But** **as** **the** **Sun**’s energy **output** slowly **increased** **over** **time**, **the** **temperature** **at** **the** **surface** **would** **eventually** **have** **risen** **above** 374°C. **Above** **this** **temperature**, **no** **matter** **what** **the** atmospheric **pressure**, Venus’ **oceans** **would** **have** **begun** **to** evaporate, **and** **the** **added** **water** vapor **in** **the** **atmosphere** **would** **have** **increased** **the** greenhouse **effect**. **This** **would** **have** **made** **the** **temperature** **even** higher **and** **caused** **the** **oceans** **to** evaporate faster, **producing** **more** **water** vapor. **That**, **in** **turn**, **would** **have** further intensified **the** greenhouse **effect** **and** **made** **the** **temperature** **climb** higher **still**.

**Once** Venus’ **oceans** **disappeared**, **so** **did** **the** mechanism **for** **removing** **carbon** **dioxide** **from** **the** **atmosphere**. **With** **no** **oceans** **to** dissolve **it**, outgassed **carbon** **dioxide** **began** **to** **accumulate** **in** **the** **atmosphere**, intensifying **the** greenhouse **effect** **even** **more**. **Temperatures** **eventually** **became** **high** **enough** **to** “**bake** **out**” **any** **carbon** **dioxide** **that** **was** **trapped** **in** carbonate **rocks**. **This** **liberated** **carbon** **dioxide** **formed** **the** **thick** **atmosphere** **of** **present**-**day** Venus. **Over** **time**, **the** **rising** **temperatures** **would** **have** leveled **off**, **solar** ultraviolet **radiation** **having** **broken** **down** atmospheric **water** vapor molecules **into** **hydrogen** **and** **oxygen**. **With** **all** **the** **water** vapor **gone**, **the** greenhouse **effect** **would** **no** longer **have** **accelerated**.

count: 183

# Official 24-Passage 02 Breathing During Sleep

**Of** **all** **the** physiological **differences** **in** **human** **sleep** **compared** **with** wakefulness **that** **have** **been** **discovered** **in** **the** **last** **decade**, **changes** **in** respiratory **control** **are** **most** dramatic. **Not** **only** **are** **there** **differences** **in** **the** **level** **of** **the** **functioning** **of** respiratory **systems**, **there** **are** **even** **changes** **in** **how** **they** **function**. **Movements** **of** **the** rib **cage** **for** **breathing** **are** **reduced** **during** **sleep**, **making** **the** contractions **of** **the** diaphragm **more** **important**. **Yet** **because** **of** **the** **physics** **of** **lying** **down**, **the** **stomach** **applies** **weight** **against** **the** diaphragm **and** **makes** **it** **more** **difficult** **for** **the** diaphragm **to** **do** **its** **job**. **However**, **there** **are** **many** **other** **changes** **that** **affect** respiration **when** **asleep**.

**During** wakefulness, **breathing** **is** **controlled** **by** **two** interacting **systems**. **The** **first** **is** an **automatic**, metabolic **system** **whose** **control** **is** centered **in** **the** **brain** stem. **It** subconsciously **adjusts** **breathing** **rate** **and** **depth** **in** **order** **to** regulate **the** **levels** **of** **carbon** **dioxide** (CO2) **and** **oxygen** (O2), **and** **the** **acid**-**base** ratio **in** **the** **blood**. **The** **second** **system** **is** **the** **voluntary**, behavioral **system**. **Its** **control** center **is** **based** **in** **the** forebrain, **and** **it** regulates **breathing** **for** **use** **in** **speech**, **singing**, **sighing**, **and** **so** **on**. **It** **is** capable **of** **ignoring** **or** overriding **the** **automatic**, metabolic **system** **and** **produces** an irregular **pattern** **of** **breathing**.

**During** NREM (**the** phase **of** **sleep** **in** **which** **there** **is** **no** **rapid** **eye** **movement**) **breathing** **becomes** deeper **and** **more** **regular**, **but** **there** **is** **also** **a** **decrease** **in** **the** **breathing** **rate**, **resulting** **in** **less** **air** **being** **exchanged** overall. **This** **occurs** **because** **during** NREM **sleep** **the** **automatic**, metabolic **system** **has** exclusive **control** **over** **breathing** **and** **the** body **uses** **less** **oxygen** **and** **produces** **less** **carbon** **dioxide**. **Also**, **during** **sleep** **the** **automatic** metabolic **system** **is** **less** responsive **to** **carbon** **dioxide** **levels** **and** **oxygen** **levels** **in** **the** **blood**. **Two** **things** **result** **from** **these** **changes** **in** **breathing** **control** **that** **occur** **during** **sleep**. **First**, **there** may **be** **a** **brief** cessation **or** reduction **of** **breathing** **when** **falling** **asleep** **as** **the** sleeper **waxes** **and** wanes **between** **sleep** **and** wakefulness **and** **their** **differing** **control** mechanisms. **Second**, **once** **sleep** **is** fully **obtained**, **there** **is** an **increase** **of** **carbon** **dioxide** **and** **a** **decrease** **of** **oxygen** **in** **the** **blood** **that** persists **during** NREM.

**But** **that** **is** **not** **all** **that** **changes**. **During** **all** phases **of** **sleep**, **several** **changes** **in** **the** **air** **passages** **have** **been** **observed**. **It** **takes** **twice** **as** **much** **effort** **to** **breathe** **during** **sleep** **because** **of** greater resistance **to** airflow **in** **the** airways **and** **changes** **in** **the** efficiency **of** **the** muscles **used** **for** **breathing**. **Some** **of** **the** muscles **that** **help** **keep** **the** **upper** airway **open** **when** **breathing** **tend** **to** **become** **more** **relaxed** **during** **sleep**, **especially** **during** REM (**the** phase **of** **sleep** **in** **which** **there** **is** **rapid** **eye** **movement**). **Without** **this** muscular **action**, inhaling **is** **like** **sucking** **air** **out** **of** **a** **balloon**—**the** **narrow** **passages** **tend** **to** collapse. **Also** **there** **is** **a** **regular** **cycle** **of** **change** **in** resistance **between** **the** **two** **sides** **of** **the** **nose**. **If** **something** **blocks** **the** “**good**” **side**, **such** **as** congestion **from** allergies **or** **a** **cold**, **then** resistance **increases** dramatically. **Coupled** **with** **these** factors **is** **the** **loss** **of** **the** **complex** interactions **among** **the** muscles **that** **can** **change** **the** route **of** airflow **from** **nose** **to** **mouth**.

**Other** respiratory regulating mechanisms apparently cease **functioning** **during** **sleep**. **For** **example**, **during** wakefulness **there** **is** an **immediate**, **automatic**, adaptive **increase** **in** **breathing** **effort** **when** inhaling **is** **made** **more** **difficult** (**such** **as** **breathing** **through** **a** restrictive **face** **mask**). **This** reflexive **adjustment** **is** **totally** **absent** **during** NREM **sleep**. **Only** after **several** inadequate **breaths** **under** **such** **conditions**, **resulting** **in** **the** considerable elevation **of** **carbon** **dioxide** **and** reduction **of** **oxygen** **in** **the** **blood**, **is** **breathing** **effort** **adjusted**. Finally, **the** **coughing** reflex **in** reaction **to** irritants **in** **the** airway **produces** **not** **a** **cough** **during** **sleep** **but** **a** cessation **of** **breathing**. **If** **the** irritation **is** **severe** **enough**, **a** **sleeping** **person** **will** arouse, **clear** resume **breathing** **and** **likely** **return** **to** **sleep**. Additional **breathing** **changes** **occur** **during** REM **sleep** **that** **are** **even** **more** dramatic **than** **the** **changes** **that** **occur** **during** NREM. **The** **amount** **of** **air** **exchanged** **is** **even** lower **in** REM **than** NREM **because**, **although** **breathing** **is** **more** **rapid** **in** REM, **it** **is** **also** **more** irregular, **with** **brief** episodes **of** **shallow** **breathing** **or** **absence** **of** **breathing**. **In** **addition**, **breathing** **during** REM **depends** **much** **more** **on** **the** **action** **of** **the** diaphragm **and** **much** **less** **on** rib **cage** **action**.

count: 183

# Official 02-Passage 02 The Origins of Cetaceans

**It** **should** **be** **obvious** **that** cetaceans--**whales**, porpoises, **and** dolphins--**are** mammals.  **They** **breathe** **through** **lungs**, **not** **through** gills, **and** **give** **birth** **to** **live** **young**.  **Their** streamlined bodies, **the** **absence** **of** hind **legs**, **and** **the** presence **of** **a** fluke **and** blowhole cannot disguise **their** affinities **with** **land**-dwelling mammals.  **However**, **unlike** **the** **cases** **of** **sea** otters **and** pinnipeds (**seals**, **sea** **lions**, **and** walruses, **whose** limbs **are** functional **both** **on** **land** **and** **at** **sea**), **it** **is** **not** **easy** **to** envision **what** **the** **first** **whales** **looked** **like**.  Extinct **but** **already** fully marine cetaceans **are** **known** **from** **the** fossil **record**.  **How** **was** **the** gap **between** **a** **walking** mammal **and** **a** **swimming** **whale** **bridged**?  **Missing** **until** recently **were** fossils **clearly** intermediate, **or** transitional, **between** **land** mammals **and** cetaceans.

**Very** **exciting** **discoveries** **have** finally **allowed** **scientists** **to** reconstruct **the** **most** **likely** **origins** **of** cetaceans.  **In** 1979, **a** **team** **looking** **for** fossils **in** **northern** Pakistan **found** **what** **proved** **to** **be** **the** oldest fossil **whale**.  **The** fossil **was** officially **named** Pakicetus **in** honor **of** **the** **country** **where** **the** **discovery** **was** **made**.  Pakicetus **was** **found** embedded **in** **rocks** **formed** **from** **river** **deposits** **that** **were** 52 **million** **years** **old**.  **The** **river** **that** **formed** **these** **deposits** **was** actually **not** **far** **from** an **ancient** **ocean** **known** **as** **the** Tethys **Sea**.

**The** fossil **consists** **of** **a** **complete** skull **of** an archaeocyte, an extinct **group** **of** **ancestors** **of** **modern** cetaceans.  **Although** **limited** **to** **a** skull, **the** Pakicetus fossil **provides** **precious** details **on** **the** **origins** **of** cetaceans.  **The** skull **is** cetacean-**like** **but** **its** jawbones **lack** **the** **enlarged** **space** **that** **is** **filled** **with** **fat** **or** **oil** **and** **used** **for** **receiving** underwater **sound** **in** **modern** **whales**.  Pakicetus **probably** detected **sound** **through** **the** **ear** **opening** **as** **in** **land** mammals.  **The** skull **also** **lacks** **a** blowhole, **another** cetacean **adaptation** **for** **diving**.  **Other** features, **however**, **show** **experts** **that** Pakicetus **is** **a** transitional **form** **between** **a** **group** **of** extinct **flesh**-**eating** mammals, **the** mesonychids, **and** cetaceans.  **It** **has** **been** **suggested** **that** Pakicetus **fed** **on** **fish** **in** **shallow** **water** **and** **was** **not** **yet** **adapted** **for** **life** **in** **the** **open** **ocean**.  **It** **probably** bred **and** **gave** **birth** **on** **land**.

**Another** **major** **discovery** **was** **made** **in** **Egypt** **in** 1989.  **Several** skeletons **of** **another** **early** **whale**, Basilosaurus, **were** **found** **in** sediments **left** **by** **the** Tethys **Sea** **and** **now** **exposed** **in** **the** Sahara **desert**.  **This** **whale** **lived** **around** 40 **million** **years** **ago**, 12 **million** **years** after Pakicetus.   **Many** incomplete skeletons **were** **found** **but** **they** **included**, **for** **the** **first** **time** **in** an archaeocyte, **a** **complete** hind **leg** **that** features **a** **foot** **with** **three** **tiny** toes.  **Such** **legs** **would** **have** **been** **far** **too** **small** **to** **have** **supported** **the** 50-**foot**-**long** Basilosaurus **on** **land**.   Basilosaurus **was** undoubtedly **a** fully marine **whale** **with** **possibly** nonfunctional, **or** vestigial, hind **legs**.

An **even** **more** **exciting** **find** **was** **reported** **in** 1994, **also** **from** Pakistan.  **The** **now** extinct **whale** Ambulocetus natans (“**the** **walking** **whale** **that** **swam**”) **lived** **in** **the** Tethys **Sea** 49 **million** **years** **ago**.  **It** **lived** **around** 3 **million** **years** after Pakicetus **but** 9 **million** **before** Basilosaurus.  **The** fossil luckily **includes** **a** **good** portion **of** **the** hind **legs**.  **The** **legs** **were** **strong** **and** **ended** **in** **long** **feet** **very** **much** **like** **those** **of** **a** **modern** pinniped.  **The** **legs** **were** **certainly** functional **both** **on** **land** **and** **at** **sea**.  **The** **whale** retained **a** **tail** **and** **lacked** **a** fluke, **the** **major** **means** **of** locomotion **in** **modern** cetaceans.  **The** structure **of** **the** backbone **shows**, **however**, **that** Ambulocetus **swam** **like** **modern** **whales** **by** **moving** **the** rear portion **of** **its** body **up** **and** **down**, **even** **though** **a** fluke **was** **missing**.  **The** **large** hind **legs** **were** **used** **for** propulsion **in** **water**.  **On** **land**, **where** **it** **probably** bred **and** **gave** **birth**, Ambulocetus may **have** **moved** **around** **very** **much** **like** **a** **modern** **sea** **lion**.  **It** **was** undoubtedly **a** **whale** **that** **linked** **life** **on** **land** **with** **life** **at** **sea**.

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Fluke: **the** **two** **parts** **that** constitute **the** **large** triangular **tail** **of** **a** **whale**

2 Blowhole: **a** **hole** **in** **the** **top** **of** **the** **head** **used** **for** **breathing**

count: 182

# Official 51-Passage 01 Memphis: United Egypt's First Capital

**The** **city** **of** Memphis, located **on** **the** Nile **near** **the** **modern** **city** **of** Cairo, **was** **founded** **around** 3100 B.C. **as** **the** **first** **capital** **of** **a** recently **united** **Egypt**. **The** **choice** **of** Memphis **by** **Egypt**’s **first** **kings** **reflects** **the** site’s strategic **importance**. **First**, **and** **most** **obvious**, **the** apex **of** **the** Nile **River** delta **was** **a** politically opportune location **for** **the** **state**’s administrative center, **standing** **between** **the** **united** **lands** **of** **Upper** **and** Lower **Egypt** **and** **offering** **ready** **access** **to** **both** **parts** **of** **the** **country**. **The** older predynastic (pre-3100 B.C.) centers **of** **power**, **This** **and** Hierakonpolis, **were** **too** **remote** **from** **the** **vast** expanse **of** **the** delta, **which** **had** **been** incorporated **into** **the** unified **state**. **Only** **a** **city** **within** **easy** **reach** **of** **both** **the** Nile **valley** **to** **the** **south** **and** **the** **more** **spread** **out**, **difficult** terrain **to** **the** **north** **could** **provide** **the** **necessary** **political** **control** **that** **the** **rulers** **of** **early** dynastic **Egypt** (roughly 3000–2600 B.C.) **required**.

**The** region **of** Memphis must **have** **also** **served** **as** an **important** node **for** **transport** **and** **communications**, **even** **before** **the** unification **of** **Egypt**. **The** region **probably** **acted** **as** **a** conduit **for** **much**, **if** **not** **all**, **of** **the** **river**-**based** **trade** **between** **northern** **and** **southern** **Egypt**. Moreover, commodities (**such** **as** **wine**, **precious** **oils**, **and** **metals**) **imported** **from** **the** **Near** **East** **by** **the** **royal** **courts** **of** predynastic **Upper** **Egypt** **would** **have** **been** **channeled** **through** **the** Memphis region **on** **their** **way** **south**. **In** **short**, **therefore**, **the** site **of** Memphis **offered** **the** **rulers** **of** **the** **Early** Dynastic **Period** an ideal location **for** **controlling** internal **trade** **within** **their** realm, an essential **requirement** **for** **a** **state**-**directed** economy **that** **depended** **on** **the** **movement** **of** **goods**.

Equally **important** **for** **the** **national** **administration** **was** **the** **ability** **to** **control** **communications** **within** **Egypt**. **The** Nile **provided** **the** easiest **and** quickest artery **of** **communication**, **and** **the** **national** **capital** **was**, **again**, ideally located **in** **this** **respect**. **Recent** geological surveys **of** **the** Memphis region **have** revealed **much** **about** **its** topography **in** **ancient** **times**. **It** **appears** **that** **the** location **of** Memphis may **have** **been** **even** **more** advantageous **for** **controlling** **trade**, **transport**, **and** **communications** **than** **was** previously **appreciated**. Surveys **and** **drill** cores **have** **shown** **that** **the** **level** **of** **the** Nile floodplain **has** steadily **risen** **over** **the** **last** **five** millenniums. **When** **the** floodplain **was** **much** lower, **as** **it** **would** **have** **been** **in** predynastic **and** **early** dynastic **times**, **the** outwash **fans** (**fan**-**shaped** **deposits** **of** sediments) **of** **various** wadis (**stream**-**beds** **or** **channels** **that** **carry** **water** **only** **during** **rainy** **periods**) **would** **have** **been** **much** **more** prominent features **on** **the** **east** **bank**. **The** **fan** **associated** **with** **the** Wadi Hof extended **a** significant **way** **into** **the** Nile floodplain, **forming** **a** constriction **in** **the** vicinity **of** Memphis. **The** **valley** may **have** **narrowed** **at** **this** **point** **to** **a** mere **three** kilometers, **making** **it** **the** ideal **place** **for** **controlling** **river** **traffic**.

Furthermore, **the** Memphis region **seems** **to** **have** **been** favorably located **for** **the** **control** **not** **only** **of** **river**-**based** **trade** **but** **also** **of** **desert** **trade** routes. **The** **two** outwash **fans** **in** **the** **area** **gave** **access** **to** **the** extensive wadi **systems** **of** **the** **eastern** **desert**. **In** predynastic **times**, **the** Wadi Digla may **have** **served** **as** **a** **trade** route **between** **the** Memphis region **and** **the** **Near** **East**, **to** **judge** **from** **the** **unusual** concentration **of** **foreign** artifacts **found** **in** **the** predynastic **settlement** **of** Maadi. **Access** **to**, **and** **control** **of**, **trade** routes **between** **Egypt** **and** **the** **Near** **East** **seems** **to** **have** **been** **a** preoccupation **of** **Egypt**’s **rulers** **during** **the** **period** **of** **state** formation. **The** **desire** **to** monopolize **foreign** **trade** may **have** **been** **one** **of** **the** **primary** factors **behind** **the** **political** unification **of** **Egypt**. **The** foundation **of** **the** **national** **capital** **at** **the** junction **of** an **important** **trade** route **with** **the** Nile **valley** **is** **not** **likely** **to** **have** **been** accidental. Moreover, **the** Wadis Hof **and** Digla **provided** **the** Memphis region **with** **accessible** **desert** pasturage. **As** **was** **the** **case** **with** **the** **cities** **of** Hierakonpolis **and** Elkab, **the** combination **within** **the** **same** **area** **of** **both** **desert** pasturage **and** alluvial arable **land** (**land** **suitable** **for** **growing** **crops**) **was** **a** particularly **attractive** **one** **for** **early** **settlement**; **this** combination **no** **doubt** **contributed** **to** **the** prosperity **of** **the** Memphis region **from** **early** predynastic **times**.

count: 181

# Official 13-Passage 03 Methods of Studying Infant Perception

**In** **the** **study** **of** perceptual **abilities** **of** infants, **a** **number** **of** **techniques** **are** **used** **to** **determine** infants’ responses **to** **various** stimuli. **Because** **they** cannot verbalize **or** **fill** **out** **questionnaires**, indirect **techniques** **of** naturalistic observation **are** **used** **as** **the** **primary** **means** **of** **determining** **what** infants **can** **see**, **hear**, **feel**, **and** **so** forth. **Each** **of** **these** **methods** **compares** an infant’s **state** prior **to** **the** **introduction** **of** **a** stimulus **with** **its** **state** **during** **or** **immediately** **following** **the** stimulus. **The** **difference** **between** **the** **two** **measures** **provides** **the** researcher **with** an indication **of** **the** **level** **and** duration **of** **the** response **to** **the** stimulus. **For** **example**, **if** **a** uniformly **moving** **pattern** **of** **some** **sort** **is** **passed** **across** **the** **visual** **field** **of** **a** neonate (newborn), repetitive **following** **movements** **of** **the** **eye** **occur**. **The** occurrence **of** **these** **eye** **movements** **provides** **evidence** **that** **the** **moving** **pattern** **is** perceived **at** **some** **level** **by** **the** newborn. Similarly, **changes** **in** **the** infant’s **general** **level** **of** **motor** **activity** — **turning** **the** **head**, blinking **the** **eyes**, **crying**, **and** **so** forth — **have** **been** **used** **by** researchers **as** **visual** indicators **of** **the** infant’s perceptual **abilities**.

**Such** **techniques**, **however**, **have** limitations. **First**, **the** observation may **be** unreliable **in** **that** **two** **or** **more** observers may **not** **agree** **that** **the** **particular** response **occurred**, **or** **to** **what** **degree** **it** **occurred**. **Second**, responses **are** **difficult** **to** quantify. **Often** **the** **rapid** **and** diffuse **movements** **of** **the** infant **make** **it** **difficult** **to** **get** an accurate **record** **of** **the** **number** **of** responses. **The** **third**, **and** **most** potent, limitation **is** **that** **it** **is** **not** **possible** **to** **be** **certain** **that** **the** infant’s response **was** **due** **to** **the** stimulus **presented** **or** **to** **a** **change** **from** **no** stimulus **to** **a** stimulus. **The** infant may **be** **responding** **to** **aspects** **of** **the** stimulus **different** **than** **those** identified **by** **the** investigator. **Therefore**, **when** observational **assessment** **is** **used** **as** **a** **technique** **for** **studying** infant perceptual **abilities**, **care** must **be** **taken** **not** **to** overgeneralize **from** **the** **data** **or** **to** **rely** **on** **one** **or** **two** **studies** **as** conclusive **evidence** **of** **a** **particular** perceptual **ability** **of** **the** infant.

Observational **assessment** **techniques** **have** **become** **much** **more** sophisticated, **reducing** **the** limitations **just** **presented**. **Film** **analysis** **of** **the** infant’s responses, **heart** **and** respiration **rate** **monitors**, **and** nonnutritive **sucking** devices **are** **used** **as** effective **tools** **in** **understanding** infant perception. **Film** **analysis** **permits** researchers **to** carefully **study** **the** infant’s responses **over** **and** **over** **and** **in** **slow** motion. **Precise** measurements **can** **be** **made** **of** **the** **length** **and** frequency **of** **the** infant’s **attention** **between** **two** stimuli. **Heart** **and** respiration **monitors** **provide** **the** investigator **with** **the** **number** **of** heartbeats **or** **breaths** **taken** **when** **a** **new** stimulus **is** **presented**. Numerical **increases** **are** **used** **as** quantifiable indicators **of** heightened **interest** **in** **the** **new** stimulus. **Increases** **in** nonnutritive **sucking** **were** **first** **used** **as** an **assessment** **measure** **by** researchers **in** 1969. **They** devised an apparatus **that** **connected** **a** baby’s pacifier **on** **to** **a** **counting** device. **As** stimuli **were** **presented**, **changes** **in** **the** infant’s **sucking** behavior **were** **recorded**. **Increases** **in** **the** **number** **of** **sucks** **were** **used** **as** an indicator **of** **the** infant’s **attention** **to** **or** **preference** **for** **a** **given** **visual** display.

**Two** additional **techniques** **of** **studying** infant perception **have** **come** **into** vogue. **The** **first** **is** **the** habituation-dishabituation **technique**, **in** **which** **a** **single** stimulus **is** **presented** repeatedly **to** **the** infant **until** **there** **is** **a** measurable **decline** (habituation) **in** **whatever** **attending** behavior **is** **being** **observed**. **At** **that** **point** **a** **new** stimulus **is** **presented**, **and** **any** recovery (dishabituation) **in** responsiveness **is** **recorded**. **If** **the** infant **fails** **to** dishabituate **and** **continues** **to** **show** habituation **with** **the** **new** stimulus, **it** **is** **assumed** **that** **the** baby **is** **unable** **to** perceive **the** **new** stimulus **as** **different**. **The** habituation-dishabituation paradigm **has** **been** **used** **most** extensively **with** **studies** **of** auditory **and** olfactory perception **in** infants. **The** **second** **technique** **relies** **on** evoked **potentials**, **which** **are** **electrical** **brain** responses **that** may **be** **related** **to** **a** **particular** stimulus **because** **of** **where** **they** originate. **Changes** **in** **the** **electrical** **pattern** **of** **the** **brain** indicate **that** **the** stimulus **is** **getting** **through** **to** **the** infant’s **central** **nervous** **system** **and** eliciting **some** **form** **of** response.

**Each** **of** **the** preceding **techniques** **provides** **the** researcher **with** **evidence** **that** **the** infant **can** detect **or** discriminate **between** stimuli. **With** **these** sophisticated observational **assessment** **and** electro physiological **measures**, **we** **know** **that** **the** neonate **of** **only** **a** **few** **days** **is** **far** **more** perceptive **than** previously **suspected**. **However**, **these** **measures** **are** **only** “indirect” indicators **of** **the** infant’s perceptual **abilities**.

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 pacifier: **a** **small** **plastic** device **for** babies **to** **suck** **or** **bite**

count: 180

# Official 29-Passage 02 Competition

**When** **several** individuals **of** **the** **same** species **or** **of** **several** **different** species **depend** **on** **the** **same** **limited** resource, **a** **situation** may **arise** **that** **is** **referred** **to** **as** **competition**. **The** **existence** **of** **competition** **has** **been** **long** **known** **to** naturalists; **its** **effects** **were** **described** **by** Darwin **in** considerable detail. **Competition** **among** individuals **of** **the** **same** species (intraspecies **competition**), **one** **of** **the** **major** mechanisms **of** **natural** selection, **is** **the** **concern** **of** evolutionary **biology**. **Competition** **among** **the** individuals **of** **different** species (interspecies **competition**) **is** **a** **major** **concern** **of** **ecology**. **It** **is** **one** **of** **the** factors **controlling** **the** **size** **of** **competing** **populations**, **and** **in** **extreme** **cases** **it** may **lead** **to** **the** extinction **of** **one** **of** **the** **competing** species. **This** **was** **described** **by** Darwin **for** indigenous **New Zealand** Zealand species **of** **animals** **and** **plants**, **which** **died** **out** **when** **competing** species **from** **Europe** **were** **introduced**.

**No** **serious** **competition** **exists** **when** **the** **major** **needed** resource **is** **in** superabundant **supply**, **as** **in** **most** **cases** **of** **the** coexistence **of** herbivores (**plant** eaters). Furthermore, **most** species **do** **not** **depend** entirely **on** **a** **single** resource. **If** **the** **major** resource **for** **a** species **becomes** scarce, **the** species **can** **usually** shift **to** **alternative** resources. **If** **more** **than** **one** species **is** **competing** **for** **a** scarce resource, **the** **competing** species **usually** **switch** **to** **different** **alternative** resources. **Competition** **is** **usually** **most** **severe** **among** **close** **relatives** **with** **similar** **demands** **on** **the** **environment**. **But** **it** may **also** **occur** **among** **totally** unrelated **forms** **that** **compete** **for** **the** **same** resource, **such** **as** **seed**-**eating** rodents **and** **ants**. **The** **effects** **of** **such** **competition** **are** graphically demonstrated **when** **all** **the** **animals** **or** **all** **the** **plants** **in** an ecosystem **come** **into** **competition**, **as** **happened** 2 **million** **years** **ago** **at** **the** **end** **of** **the** Pliocene, **when** **North** **and** **South** **America** **became** **joined** **by** **the** Isthmus **of** Panama. **North** **and** **South** **American** species migrating **across** **the** Isthmus **now** **came** **into** **competition** **with** **each** **other**. **The** **result** **was** **the** extermination **of** **a** **large** fraction **of** **the** **South** **American** mammals, **which** **were** apparently **unable** **to** withstand **the** **competition** **from** invading **North** **American** species—**although** **added** predation **was** **also** an **important** factor.

**To** **what** extent **competition** **determines** **the** **composition** **of** **a** community **and** **the** density **of** **particular** species **has** **been** **the** source **of** considerable controversy. **The** **problem** **is** **that** **competition** ordinarily cannot **be** **observed** directly **but** must **be** inferred **from** **the** **spread** **or** **increase** **of** **one** species **and** **the** concurrent reduction **or** disappearance **of** **another** species. **The** **Russian** biologist G.**F**. Gause **performed** numerous **two**-species **experiments** **in** **the** laboratory, **in** **which** **one** **of** **the** species **became** extinct **when** **only** **a** **single** **kind** **of** resource **was** **available**. **On** **the** **basis** **of** **these** **experiments** **and** **of** **field** observations, **the** **so**-**called** **law** **of** competitive exclusion **was** formulated, **according to** **which** **no** **two** species **can** occupy **the** **same** niche. Numerous **seeming** exceptions **to** **this** **law** **have** **since** **been** **found**, **but** **they** **can** **usually** **be** **explained** **as** **cases** **in** **which** **the** **two** species, **even** **though** **competing** **for** **a** **major** joint resource, **did** **not** **really** occupy **exactly** **the** **same** niche.

**Competition** **among** species **is** **of** considerable evolutionary **importance**. **The** **physical** structure **of** species **competing** **for** resources **in** **the** **same** ecological niche **tends** **to** **gradually** evolve **in** **ways** **that** **allow** **them** **to** occupy **different** niches. **Competing** species **also** **tend** **to** **change** **their** **ranges** **so** **that** **their** territories **no** longer overlap. **The** evolutionary **effect** **of** **competition** **on** species **has** **been** **referred** **to** **as** “species selection;” **however**, **this** **description** **is** potentially misleading. **Only** **the** individuals **of** **a** species **are** **subject** **to** **the** **pressures** **of** **natural** selection. **The** **effect** **on** **the** **well**-**being** **and** **existence** **of** **a** species **is** **just** **the** **result** **of** **the** **effects** **of** selection **on** **all** **the** individuals **of** **the** species. **Thus** species selection **is** actually **a** **result** **of** individual selection. **Competition** may **occur** **for** **any** **needed** resource. **In** **the** **case** **of** **animals** **it** **is** **usually** **food**; **in** **the** **case** **of** **forest** **plants** **it** may **be** **light**; **in** **the** **case** **of** substrate inhabitants **it** may **be** **space**, **as** **in** **many** **shallow**-**water** **bottom**-dwelling marine organisms. **Indeed**, **it** may **be** **for** **any** **of** **the** factors, **physical** **as** **well** **as** biotic, **that** **are** essential **for** organisms. **Competition** **is** **usually** **the** **more** **severe** **the** denser **the** **population**. **Together** **with** predation, **it** **is** **the** **most** **important** density-dependent factor **in** regulating **population** **growth**.

count: 178

# Official 32-Passage 01 Plant Colonization

Colonization **is** **one** **way** **in** **which** **plants** **can** **change** **the** **ecology** **of** **a** site. Colonization **is** **a** **process** **with** **two** **components**: invasion **and** **survival**. **The** **rate** **at** **which** **a** site **is** colonized **by** **plants** **depends** **on** **both** **the** **rate** **at** **which** individual organisms (**seeds**, spores, immature **or** **mature** individuals) **arrive** **at** **the** site **and** **their** **success** **at** **becoming** established **and** **surviving**. **Success** **in** colonization **depends** **to** **a** **great** extent **on** **there** **being** **a** site **available** **for** colonization—**a** **safe** site **where** disturbance **by** **fire** **or** **by** **cutting** **down** **of** **trees** **has** **either** **removed** **competing** species **or** **reduced** **levels** **of** **competition** **and** **other** negative interactions **to** **a** **level** **at** **which** **the** invading species **can** **become** established. **For** **a** **given** **rate** **of** invasion, colonization **of** **a** moist, fertile site **is** **likely** **to** **be** **much** **more** **rapid** **than** **that** **of** **a** **dry**, infertile site **because** **of** **poor** **survival** **on** **the** **latter**. **A** fertile, plowed **field** **is** rapidly invaded **by** **a** **large** **variety** **of** **weeds**, whereas **a** neighboring **construction** site **from** **which** **the** **soil** **has** **been** compacted **or** **removed** **to** **expose** **a** coarse, infertile **parent** **material** may **remain** virtually **free** **of** vegetation **for** **many** **months** **or** **even** **years** despite **receiving** **the** **same** input **of** **seeds** **as** **the** plowed **field**.

**Both** **the** **rate** **of** invasion **and** **the** **rate** **of** extinction vary greatly **among** **different** **plant** species.**Pioneer** species—**those** **that** **occur** **only** **in** **the** earliest **stages** **of** colonization—**tend** **to** **have** **high** **rates** **of** invasion **because** **they** **produce** **very** **large** **numbers** **of** reproductive propagules (**seeds**, spores, **and** **so** **on**) **and** **because** **they** **have** an efficient **means** **of** dispersal (normally, **wind**).

**If** colonizers **produce** **short**-**lived** reproductive propagules, **then** **they** must **produce** **very** **large** **numbers** **unless** **they** **have** an efficient **means** **of** dispersal **to** **suitable** **new** habitats. **Many** **plants** **depend** **on** **wind** **for** dispersal **and** **produce** **abundant** **quantities** **of** **small**, relatively **short**-**lived** **seeds** **to** **compensate** **for** **the** **fact** **that** **wind** **is** **not** **always** **a** **reliable** **means** **of** **reaching** **the** **appropriate** **type** **of** habitat. **Alternative** strategies **have** evolved **in** **some** **plants**, **such** **as** **those** **that** **produce** fewer **but** larger **seeds** **that** **are** dispersed **to** **suitable** sites **by** **birds** **or** **small** mammals **or** **those** **that** **produce** **long**-**lived** **seeds**. **Many** **forest** **plants** **seem** **to** exhibit **the** **latter** **adaptation**, **and** viable **seeds** **of** **pioneer** species **can** **be** **found** **in** **large** **numbers** **on** **some** **forest** **floors**. **For** **example**, **as** **many** **as** 1,125 viable **seeds** **per** **square** meter **were** **found** **in** **a** 100-**year**-**old** Douglas fir/**western** hemlock **forest** **in** coastal **British** Columbia. **Nearly** **all** **the** **seeds** **that** **had** germinated **from** **this** **seed** **bank** **were** **from** **pioneer** species. **The** **rapid** colonization **of** **such** sites after disturbance **is** undoubtedly **in** **part** **a** reflection **of** **the** **large** **seed** **bank** **on** **the** **forest** **floor**.

An **adaptation** **that** **is** **well** **developed** **in** colonizing species **is** **a** **high** **degree** **of** variation **in** germination (**the** **beginning** **of** **a** **seed**’s **growth**). **Seeds** **of** **a** **given** species exhibit **a** **wide** **range** **of** germination **dates**, **increasing** **the** probability **that** **at** **least** **some** **of** **the** **seeds** **will** germinate **during** **a** **period** **of** favorable environmental **conditions**. **This** **is** particularly **important** **for** species **that** colonize an **environment** **where** **there** **is** **no** **existing** vegetation **to** ameliorate climatic **extremes** **and** **in** **which** **there** may **be** **great** climatic diversity.

Species succession **in** **plant** communities, i.e., **the** temporal sequence **of** **appearance** **and** disappearance **of** species, **is** dependent **on** **events** **occurring** **at** **different** **stages** **in** **the** **life** **history** **of** **a** species. Variation **in** **rates** **of** invasion **and** **growth** **plays** an **important** **role** **in** **determining** **patterns** **of** succession, **especially** secondary succession. **The** species **that** **are** **first** **to** colonize **a** site **are** **those** **that** **produce** **abundant** **seed** **that** **is** **distributed** successfully **to** **new** sites. **Such** species generally **grow** rapidly **and** quickly dominate **new** sites, excluding **other** species **with** lower invasion **and** **growth** **rates**. **The** **first** community **that** occupies **a** **disturbed** **area** **therefore** may **be** composed **of** species **with** **the** highest **rate** **of** invasion, whereas **the** community **of** **the** subsequent **stage** may **consist** **of** **plants** **with** **similar** **survival** **rates** **but** lower invasion **rates**.

count: 178

# Official 52-Passage 01 Stream Deposits

**A** **large**, **swift** **stream** **or** **river** **can** **carry** **all** **sizes** **of** particles, **from** **clay** **to** boulders. **When** **the** current **slows** **down**, **its** **competence** (**how** **much** **it** **can** **carry**) **decreases** **and** **the** **stream** **deposits** **the** largest particles **in** **the** streambed. **If** current velocity **continues** **to** **decrease**—**as** **a** **flood** wanes, **for** **example**—finer particles **settle** **out** **on** **top** **of** **the** **large** **ones**. **Thus**, **a** **stream** **sorts** **its** sediment **according to** **size**. **A** waning **flood** **might** **deposit** **a** layer **of** gravel, overlain **by** **sand** **and** finally **topped** **by** silt **and** **clay**. **Streams** **also** **sort** sediment **in** **the** downstream **direction**. **Many** **mountain** **streams** **are** **choked** **with** boulders **and** cobbles, **but** **far** downstream, **their** deltas **are** composed mainly **of** **fine** silt **and** **clay**. **This** downstream **sorting** **is** **curious** **because** **stream** velocity generally **increases** **in** **the** downstream **direction**. **Competence** **increases** **with** velocity, **so** **a** **river** **should** **be** **able** **to** **transport** larger particles **than** **its** tributaries **carry**. **One** **explanation** **for** downstream **sorting** **is** **that** abrasion **wears** **away** **the** boulders **and** cobbles **to** **sand** **and** silt **as** **the** sediment **moves** downstream **over** **the** **years**. **Thus**, **only** **the** **fine** sediment **reaches** **the** lower **parts** **of** **most** **rivers**.

**A** **stream** **deposits** **its** sediment **in** **three** **environments**: Alluvial **fans** **and** deltas **form** **where** **stream** gradient (**angle** **of** incline) suddenly **decreases** **as** **a** **stream** **enters** **a** **flat** **plain**, **a** **lake**, **or** **the** **sea**; floodplain **deposits** **accumulate** **on** **a** floodplain adjacent **to** **the** **stream** **channel**; **and** **channel** **deposits** **form** **in** **the** **stream** **channel** **itself**. **Bars**, **which** **are** elongated mounds **of** sediment, **are** transient features **that** **form** **in** **the** **stream** **channel** **and** **on** **the** **banks**. **They** commonly **form** **in** **one** **year** **and** erode **the** **next**. **Rivers** **used** **for** commercial navigation must **be** recharged frequently **because** **bars** shift **from** **year** **to** **year**. **Imagine** **a** **winding** **stream**. **The** **water** **on** **the** **outside** **of** **the** curve **moves** faster **than** **the** **water** **on** **the** **inside**. **The** **stream** erodes **its** **outside** **bank** **because** **the** current’s inertia **drives** **it** **into** **the** **outside** **bank**. **At** **the** **same** **time**, **the** slower **water** **on** **the** **inside** **point** **of** **the** **bend** **deposits** sediment, **forming** **a** **point** **bar**. **A** mid-**channel** **bar** **is** **a** sandy **and** gravelly **deposit** **that** **forms** **in** **the** **middle** **of** **a** **stream** **channel**.

**Most** **streams** **flow** **in** **a** **single** **channel**. **In** contrast, **a** braided **stream** **flows** **in** **many** **shallow**, interconnecting **channels**. **A** braided **stream** **forms** **where** **more** sediment **is** **supplied** **to** **a** **stream** **than** **it** **can** **carry**. **The** **stream** dumps **the** excess sediment, **forming** mid-**channel** **bars**. **The** **bars** **gradually** **fill** **a** **channel**, **forcing** **the** **stream** **to** overflow **its** **banks** **and** erode **new** **channels**. **As** **a** **result**, **a** braided **stream** **flows** simultaneously **in** **several** **channels** **and** shifts **back** **and** forth **across** **its** floodplain. Braided **streams** **are** **common** **in** **both** **deserts** **and** glacial **environments** **because** **both** **produce** **abundant** sediment. **A** **desert** yields **large** **amounts** **of** sediment **because** **it** **has** **little** **or** **no** vegetation **to** **prevent** erosion. Glaciers grind bedrock **into** **fine** sediment, **which** **is** **carried** **by** **streams** **flowing** **from** **the** melting **ice**. **If** **a** **steep** **mountain** **stream** **flows** **onto** **a** **flat** **plain**, **its** gradient **and** velocity **decrease** sharply. **As** **a** **result**, **it** **deposits** **most** **of** **its** sediment **in** **a** **fan**-**shaped** mound **called** an alluvial **fan**. Alluvial **fans** **are** **common** **in** **many** arid **and** semiarid **mountainous** regions.

**A** **stream** **also** **slows** abruptly **where** **it** **enters** **the** **still** **water** **of** **a** **lake** **or** **ocean**. **The** sediment **settles** **out** **to** **form** **a** **nearly** **flat** landform **called** **a** delta. **Part** **of** **the** delta **lies** **above** **water** **level**, **and** **the** remainder **lies** slightly **below** **water** **level**. Deltas **are** commonly **fan**-**shaped**, **resembling** **the** **Greek** **letter** “delta” (Δ). **Both** deltas **and** alluvial **fans** **change** rapidly. Sediment **fills** **channels** (waterways), **which** **are** **then** **abandoned** **while** **new** **channels** **develop** **as** **in** **a** braided **stream**. **As** **a** **result**, **a** **stream** **feeding** **a** delta **or** **fan** **splits** **into** **many** **channels** **called** distributaries. **A** **large** delta may **spread** **out** **in** **this** **manner** **until** **it** **covers** **thousands** **of** **square** kilometers. **Most** **fans**, **however**, **are** **much** smaller, **covering** **a** fraction **of** **a** **square** kilometer **to** **a** **few** **square** kilometers. **The** Mississippi **River** **has** **flowed** **through** **seven** **different** delta **channels** **during** **the** **past** 5,000 **to** 6,000 **years**. **But** **in** **recent** **years**, **engineers** **have** **built** **great** **systems** **of** levees (retaining **walls**) **in** **attempts** **to** stabilize **the** **channels**.

count: 177

# Official 16-Passage 03 Planets in Our Solar System

**The** **Sun** **is** **the** hub **of** **a** **huge** rotating **system** **consisting** **of** **nine** **planets**, **their** **satellites**, **and** numerous **small** bodies, **including** asteroids, comets, **and** meteoroids. An estimated 99.85 **percent** **of** **the** **mass** **of** **our** **solar** **system** **is** **contained** **within** **the** **Sun**, **while** **the** **planets** collectively **make** **up** **most** **of** **the** **remaining** 0.15 **percent**. **The** **planets**, **in** **order** **of** **their** **distance** **from** **the** **Sun**, **are** Mercury, Venus, **Earth**, Mars, Jupiter, Saturn, Uranus, Neptune, **and** Pluto. **Under** **the** **control** **of** **the** **Sun**’s gravitational **force**, **each** **planet** maintains an elliptical **orbit** **and** **all** **of** **them** **travel** **in** **the** **same** **direction**.

**The** **planets** **in** **our** **solar** **system** **fall** **into** **two** **groups**: **the** terrestrial (**Earth**-**like**) **planets** (Mercury, Venus, **Earth**, **and** Mars) **and** **the** Jovian (Jupiter-**like**) **planets** (Jupiter, Saturn, Uranus, **and** Neptune). Pluto **is** **not** **included** **in** **either** **category**, **because** **its** **great** **distance** **from** **Earth** **and** **its** **small** **size** **make** **this** **planet**’s **true** **nature** **a** mystery.

**The** **most** **obvious** **difference** **between** **the** terrestrial **and** **the** Jovian **planets** **is** **their** **size**. **The** largest terrestrial **planet**, **Earth** **has** **a** diameter **only** **one** **quarter** **as** **great** **as** **the** diameter **of** **the** smallest Jovian **planet**, Neptune, **and** **its** **mass** **is** **only** **one** seventeenth **as** **great**. Hence, **the** Jovian **planets** **are** **often** **called** giants. **Also**, **because** **of** **their** **relative** locations, **the** **four** Jovian **planets** **are** **known** **as** **the** **outer** **planets**, **while** **the** terrestrial **planets** **are** **known** **as** **the** inner **planets**. **There** **appears** **to** **be** **a** correlation **between** **the** **positions** **of** **these** **planets** **and** **their** **sizes**.

**Other** **dimensions** **along** **which** **the** **two** **groups** **differ** markedly **are** density **and** **composition**. **The** densities **of** **the** terrestrial **planets** **average** **about** 5 **times** **the** density **of** **water**, whereas **the** Jovian **planets** **have** densities **that** **average** **only** 1.5 **times** **the** density **of** **water**. **One** **of** **the** **outer** **planets**, Saturn, **has** **a** density **of** **only** 0.7 **that** **of** **water**, **which** **means** **that** Saturn **would** **float** **in** **water**. Variations **in** **the** **composition** **of** **the** **planets** **are** largely responsible **for** **the** density **differences**. **The** substances **that** **make** **up** **both** **groups** **of** **planets** **are** **divided** **into** **three** **groups**—**gases**, **rocks**, **and** **ices**—**based** **on** **their** melting **points**. **The** terrestrial **planets** **are** mostly **rocks**: dense rocky **and** metallic **material**, **with** minor **amounts** **of** **gases**. **The** Jovian **planets**, **on** **the** **other** **hand**, **contain** **a** **large** **percentage** **of** **the** **gases** **hydrogen** **and** helium, **with** varying **amounts** **of** **ices**: mostly **water**, ammonia, **and** methane **ices**.

**The** Jovian **planets** **have** **very** **thick** **atmospheres** **consisting** **of** varying **amounts** **of** **hydrogen**, helium, methane, **and** ammonia. **By** comparison, **the** terrestrial **planets** **have** meager **atmospheres** **at** **best**. **A** **planet**’s **ability** **to** retain an **atmosphere** **depends** **on** **its** **temperature** **and** **mass**. **Simply** **stated**, **a** **gas** molecule **can** “evaporate” **from** **a** **planet** **if** **it** **reaches** **a** **speed** **known** **as** **the** **escape** velocity. **For** **Earth**, **this** velocity **is** 11 kilometers **per** **second**. **Any** **material**, **including** **a** **rocket**, must **reach** **this** **speed** **before** **it** **can** **leave** **Earth** **and** **go** **into** **space**. **The** Jovian **planets**, **because** **of** **their** greater **masses** **and** **thus** higher **surface** **gravities**, **have** higher **escape** velocities (21–60 kilometers **per** **second**) **than** **the** terrestrial **planets**. Consequently, **it** **is** **more** **difficult** **for** **gases** **to** “evaporate” **from** **them**. **Also**, **because** **the** molecular motion **of** **a** **gas** **depends** **on** **temperature**, **at** **the** **low** **temperatures** **of** **the** Jovian **planets** **even** **the** lightest **gases** **are** unlikely **to** **acquire** **the** **speed** **needed** **to** **escape**. **On** **the** **other** **hand**, **a** comparatively **warm** body **with** **a** **small** **surface** **gravity**, **like** **Earth**’s **moon**, **is** **unable** **to** **hold** **even** **the** heaviest **gas** **and** **thus** **lacks** an **atmosphere**. **The** slightly larger terrestrial **planets** **Earth**, Venus, **and** Mars retain **some** **heavy** **gases** **like** **carbon** **dioxide**, **but** **even** **their** **atmospheres** **make** **up** **only** an infinitesimally **small** portion **of** **their** **total** **mass**.

**The** orderly **nature** **of** **our** **solar** **system** **leads** **most** **astronomers** **to** **conclude** **that** **the** **planets** **formed** **at** essentially **the** **same** **time** **and** **from** **the** **same** **material** **as** **the** **Sun**. **It** **is** hypothesized **that** **the** primordial **cloud** **of** **dust** **and** **gas** **from** **which** **all** **the** **planets** **are** **thought** **to** **have** condensed **had** **a** **composition** somewhat **similar** **to** **that** **of** Jupiter. **However**, **unlike** Jupiter, **the** terrestrial **planets** **today** **are** **nearly** void **of** **light** **gases** **and** **ices**. **The** **explanation** may **be** **that** **the** terrestrial **planets** **were** **once** **much** larger **and** richer **in** **these** **materials** **but** **eventually** **lost** **them** **because** **of** **these** bodies’ **relative** closeness **to** **the** **Sun**, **which** **meant** **that** **their** **temperatures** **were** relatively **high**.

count: 176

# Official 09-Passage 01 Colonizing the Americas via the Northwest Coast

**It** **has** **long** **been** **accepted** **that** **the** Americas **were** colonized **by** **a** migration **of** **peoples** **from** **Asia**, slowly traveling **across** **a** **land** **bridge** **called** Beringia (**now** **the** Bering **Strait** **between** northeastern **Asia** **and** Alaska) **during** **the** **last** **Ice** **Age**. **The** **first** **water** craft **theory** **about** **this** migration **was** **that** **around** 11,000–12,000 **years** **ago** **there** **was** an **ice**-**free** corridor stretching **from** **eastern** Beringia **to** **the** **areas** **of** **North** **America** **south** **of** **the** **great** **northern** glaciers. **It** **was** **this** midcontinental corridor **between** **two** massive **ice** **sheets**—**the** Laurentide **to** **the** **east** **and** **the** Cordilleran **to** **the** **west**—**that** enabled **the** southward migration. **But** **belief** **in** **this** **ice**-**free** corridor **began** **to** crumble **when** paleoecologist Glen MacDonald demonstrated **that** **some** **of** **the** **most** **important** radiocarbon **dates** **used** **to** **support** **the** **existence** **of** an **ice**-**free** corridor **were** **incorrect**. **He** persuasively **argued** **that** **such** an **ice**-**free** corridor **did** **not** **exist** **until** **much** **later**, **when** **the** continental **ice** **began** **its** **final** retreat.

**Support** **is** **growing** **for** **the** **alternative** **theory** **that** **people** **using** watercraft, **possibly** **skin** **boats**, **moved** southward **from** Beringia **along** **the** Gulf **of** Alaska **and** **then** southward **along** **the** **Northwest** **Coast** **of** **North** **America** **possibly** **as** **early** **as** 16,000 **years** **ago**. **This** route **would** **have** enabled **humans** **to** **enter** **southern** **areas** **of** **the** Americas prior **to** **the** melting **of** **the** continental glaciers. **Until** **the** **early** 1970s, **most** archaeologists **did** **not** **consider** **the** **coast** **a** **possible** migration route **into** **the** Americas **because** geologists originally **believed** **that** **during** **the** **last** **Ice** **Age** **the** **entire** **Northwest** **Coast** **was** **covered** **by** glacial **ice**. **It** **had** **been** **assumed** **that** **the** **ice** extended westward **from** **the** Alaskan/**Canadian** **mountains** **to** **the** **very** **edge** **of** **the** continental **shelf**, **the** **flat**, submerged **part** **of** **the** **continent** **that** extends **into** **the** **ocean**. **This** **would** **have** **created** **a** **barrier** **of** **ice** extending **from** **the** Alaska Peninsula, **through** **the** Gulf **of** Alaska **and** southward **along** **the** **Northwest** **Coast** **of** **North** **America** **to** **what** **is** **today** **the** **state** **of** Washington.

**The** **most** influential proponent **of** **the** coastal migration route **has** **been** **Canadian** archaeologist Knut Fladmark. **He** theorized **that** **with** **the** **use** **of** watercraft, **people** **gradually** colonized unglaciated refuges **and** **areas** **along** **the** continental **shelf** **exposed** **by** **the** lower **sea** **level**. Fladmark’s hypothesis **received** additional **support** **from** **the** **fact** **that** **the** greatest diversity **in** **Native** **American** **languages** **occurs** **along** **the** **west** **coast** **of** **the** Americas, **suggesting** **that** **this** region **has** **been** **settled** **the** longest.

**More** **recent** geologic **studies** **documented** deglaciation **and** **the** **existence** **of** **ice**-**free** **areas** **throughout** **major** coastal **areas** **of** **British** Columbia, **Canada**, **by** 13,000 **years** **ago**. **Research** **now** indicates **that** sizable **areas** **of** southeastern Alaska **along** **the** inner continental **shelf** **were** **not** **covered** **by** **ice** **toward** **the** **end** **of** **the** **last** **Ice** **Age**. **One** **study** **suggests** **that** **except** **for** **a** 250-**mile** coastal **area** **between** southwestern **British** Columbia **and** Washington **State**, **the** **Northwest** **Coast** **of** **North** **America** **was** largely **free** **of** **ice** **by** **approximately** 16,000 **years** **ago**. **Vast** **areas** **along** **the** **coast** may **have** **been** deglaciated **beginning** **around** 16,000 **years** **ago**, **possibly** **providing** **a** coastal corridor **for** **the** **movement** **of** **plants**, **animals**, **and** **humans** sometime **between** 13,000 **and**14,000 **years** **ago**.

**The** coastal hypothesis **has** **gained** **increasing** **support** **in** **recent** **years** **because** **the** **remains** **of** **large** **land** **animals**, **such** **as** caribou **and** **brown** **bears**, **have** **been** **found** **in** southeastern Alaska **dating** **between** 10,000 **and** 12,500 **years** **ago**. **This** **is** **the** **time** **period** **in** **which** **most** **scientists** formerly **believed** **the** **area** **to** **be** inhospitable **for** **humans**. **It** **has** **been** **suggested** **that** **if** **the** **environment** **were** capable **of** **supporting** breeding **populations** **of** **bears**, **there** **would** **have** **been** **enough** **food** resources **to** **support** **humans**. Fladmark **and** **others** **believe** **that** **the** **first** **human** colonization **of** **America** **occurred** **by** **boat** **along** **the** **Northwest** **Coast** **during** **the** **very** **late** **Ice** **Age**, **possibly** **as** **early** **as** 14,000 **years** **ago**. **The** **most** **recent** geologic **evidence** indicates **that** **it** may **have** **been** **possible** **for** **people** **to** colonize **ice**-**free** regions **along** **the** continental **shelf** **that** **were** **still** **exposed** **by** **the** lower **sea** **level** **between** 13,000 **and** 14,000 **years** **ago**.

**The** coastal hypothesis **suggests** an economy **based** **on** marine mammal **hunting**, saltwater **fishing**, shellfish **gathering**, **and** **the** **use** **of** watercraft. **Because** **of** **the** **barrier** **of** **ice** **to** **the** **east**, **the Pacific Ocean** **Ocean** **to** **the** **west**, **and** populated **areas** **to** **the** **north**, **there** may **have** **been** **a** greater impetus **for** **people** **to** **move** **in** **a** southerly **direction**.

count: 176

# Official 45-Passage 03 Feeding Strategies in the Ocean

**In** **the** **near**-**surface** layers, **there** **are** **many** **large**, **fast** carnivores **as** **well** **as** an immense **variety** **of** planktonic **animals**, **which** **feed** **on** plankton (**small**, **free**-**floating** **plants** **or** **animals**) **by** filtering **them** **from** currents **of** **water** **that** **pass** **through** **a** specialized anatomical structure. **These** filter-feeders thrive **in** **the** **well**-illuminated **surface** **waters** **because** **oceans** **have** **so** **many** **very** **small** organisms, **from** **bacteria** **to** **large** algae **to** larval crustaceans. **Even** **fishes** **can** **become** **successful** filter-feeders **in** **some** **circumstances**. **Although** **the** **vast** **majority** **of** marine **fishes** **are** carnivores, **in** **near**-**surface** regions **of** **high** productivity **the** concentrations **of** larger phytoplankton (**the** **plant** **component** **of** plankton) **are** sufficient **to** **support** **huge** **populations** **of** filter-**feeding** sardines **and** anchovies. **These** **small** **fishes** **use** **their** gill filaments **to** strain **out** **the** algae **that** dominate **such** **areas**. Sardines **and** anchovies **provide** **the** **basis** **for** **huge** commercial fisheries **as** **well** **as** **a** **food** resource **for** **large** **numbers** **of** **local** carnivores, particularly seabirds. **At** **a** **much** larger scale, baleen **whales** **and** **whale** **sharks** **are** **also** efficient filter-feeders **in** productive coastal **or** polar **waters**, **although** **their** filtered particles comprise **small** **animals** **such** **as** copepods **and** krill **rather** **than** phytoplankton.

    Filtering seawater **for** **its** particulate nutritional **content** **can** **be** an energetically **demanding** **method** **of** **feeding**, particularly **when** **the** current **of** **water** **to** **be** filtered **has** **to** **be** generated **by** **the** organism **itself**, **as** **is** **the** **case** **for** **all** planktonic **animals**. Particulate organic **matter** **of** **at** **least** 2.5 micrograms **per** **cubic** liter **is** **required** **to** **provide** **a** filter-**feeding** planktonic organism **with** **a** **net** energy **gain**. **This** **value** **is** **easily** exceeded **in** **most** coastal **waters**, **but** **in** **the** **deep** **sea**, **the** **levels** **of** organic **matter** **range** **from** **next** **to** **nothing** **to** **around** 7 micrograms **per** **cubic** liter. **Even** **though** **mean** **levels** may **mask** **much** higher **local** concentrations, **it** **is** **still** **the** **case** **that** **many** **deep**-**sea** **animals** **are** **exposed** **to** **conditions** **in** **which** **a** **normal** filter-feeder **would** **starve**.

**There** **are**, **therefore**, fewer **successful** filter-feeders **in** **deep** **water**, **and** **some** **of** **those** **that** **are** **there** **have** larger filtering **systems** **to** cope **with** **the** scarcity **of** particles. **Another** solution **for** **such** **animals** **is** **to** forage **in** **particular** layers **of** **water** **where** **the** particles may **be** **more** **concentrated**. **Many** **of** **the** **groups** **of** **animals** **that** typify **the** filter-**feeding** lifestyle **in** **shallow** **water** **have** **deep**-**sea** **representatives** **that** **have** **become** predatory. **Their** filtering **systems**, **which** **reach** **such** **a** **high** **degree** **of** **development** **in** **shallow**-**water** species, **are** greatly **reduced**. **Alternative** **methods** **of** **active** **or** **passive** prey capture **have** **been** evolved, **including** **trapping** **and** **seizing** prey, entangling prey, **and** sticky tentacles.

**In** **the** deeper **waters** **of** **the** **oceans**, **there** **is** **a** **much** greater **tendency** **for** **animals** **to** await **the** **arrival** **of** **food** particles **or** prey **rather** **than** **to** **search** **them** **out** actively (**thus** minimizing energy expenditure). **This** **has** **resulted** **in** **a** **more** stealthy **style** **of** **feeding**, **with** **the** consequent emphasis **on** lures **and**/**or** **the** **evolution** **of** elongated appendages **that** **increase** **the** **active** volume **of** **water** **controlled** **or** **monitored** **by** **the** **animal**. **Another** **consequence** **of** **the** **limited** availability **of** prey **is** **that** **many** **animals** **have** **developed** **ways** **of** coping **with** **much** larger **food** particles, **relative** **to** **their** **own** body **size**, **than** **the** equivalent shallower species **can** **process**. **Among** **the** **fishes** **there** **is** **a** **tendency** **for** **the** **teeth** **and** **jaws** **to** **become** appreciably **enlarged**. **In** **such** **creatures**, **not** **only** **are** **the** **teeth** hugely **enlarged** **and**/**or** **the** **jaws** elongated **but** **the** **size** **of** **the** **mouth** **opening** may **be** greatly **increased** **by** **making** **the** **jaw** articulations **so** **flexible** **that** **they** **can** **be** effectively dislocated. **Very** **large** **or** **long** **teeth** **provide** **almost** **no** **room** **for** **cutting** **the** prey **into** **a** **convenient** **size** **for** **swallowing**; **the** **fish** must gulp **the** prey **down** **whole**.

count: 175

# Official 32-Passage 03 Distributions of Tropical Bee Colonies

**In** 1977 ecologists Stephen Hubbell **and** Leslie Johnson **recorded** **a** dramatic **example** **of** **how** **social** interactions **can** **produce** **and** enforce **regular** **spacing** **in** **a** **population**. **They** **studied** **competition** **and** **nest** **spacing** **in** **populations** **of** stingless **bees** **in** tropical **dry** **forests** **in** Costa Rica. **Though** **these** **bees** **do** **not** sting, rival colonies **of** **some** species **fight** fiercely **over** **potential** **nesting** sites.

Stingless **bees** **are** **abundant** **in** tropical **and** subtropical **environments**, **where** **they** **gather** nectar **and** pollen **from** **a** **wide** **variety** **of** **flowers**. **They** generally **nest** **in** **trees** **and** **live** **in** colonies **made** **up** **of** **hundreds** **to** **thousands** **of** **workers**. Hubbell **and** Johnson **observed** **that** **some** species **of** stingless **bees** **are** highly **aggressive** **to** **members** **of** **their** species **from** **other** colonies, **while** **other** species **are** **not**. **Aggressive** species **usually** forage **in** **groups** **and** **feed** mainly **on** **flowers** **that** **occur** **in** **high**-density clumps. Nonaggressive species **feed** singly **or** **in** **small** **groups** **and** **on** **more** widely **distributed** **flowers**.

Hubbell **and** Johnson **studied** **several** species **of** stingless **bees** **to** **determine** **whether** **there** **is** **a** **relationship** **between** aggressiveness **and** **patterns** **of** colony distribution. **They** **predicted** **that** **the** colonies **of** **aggressive** species **would** **show** **regular** distributions, **while** **those** **of** nonaggressive species **would** **show** **random** **or** closely **grouped** (clumped) distributions. **They** **concentrated** **their** **studies** **on** **a** **thirteen**-hectare tract **of** tropical **dry** **forest** **that** **contained** numerous **nests** **of** **nine** species **of** stingless **bees**.

**Though** Hubbell **and** Johnson **were** **interested** **in** **how** **bee** behavior **might** **affect** colony distributions, **they** recognized **that** **the** availability **of** **potential** **nest** sites **for** colonies **could** **also** **affect** distributions. **So** **as** **one** **of** **the** **first** **steps** **in** **their** **study**, **they** **mapped** **the** distributions **of** **trees** **suitable** **for** **nesting**. **They** **found** **that** **potential** **nest** **trees** **were** **distributed** randomly **through** **the** **study** **area**. **They** **also** **found** **that** **the** **number** **of** **potential** **nest** sites **was** **much** greater **than** **the** **number** **of** **bee** colonies. **What** **did** **these** measurements **show** **the** researchers? **The** **number** **of** colonies **in** **the** **study** **area** **was** **not** **limited** **by** availability **of** **suitable** **trees**, **and** **a** clumped **or** **regular** distribution **of** colonies **was** **not** **due** **to** an underlying clumped **or** **regular** distribution **of** **potential** **nest** sites.

Hubbell **and** Johnson **mapped** **the** **nests** **of** **five** **of** **the** **nine** species **of** stingless **bees** accurately, **and** **the** **nests** **of** **four** **of** **these** species **were** **distributed** regularly. **All** **four** species **with** **regular** **nest** distributions **were** highly **aggressive** **to** **bees** **from** **other** colonies **of** **their** **own** species. **The** **fifth** species **was** **not** **aggressive**, **and** **its** **nests** **were** randomly **distributed** **over** **the** **study** **area**.

**The** researchers **also** **studied** **the** **process** **by** **which** **the** **aggressive** species establish **new** colonies. **Their** observations **provide** insights **into** **the** mechanisms **that** establish **and** maintain **the** **regular** **nest** distribution **of** **these** species. **Aggressive** species apparently **mark** prospective **nest** sites **with** pheromones, **chemical** substances **secreted** **by** **some** **animals** **for** **communication** **with** **other** **members** **of** **their** species. **The** pheromone **secreted** **by** **these** stingless **bees** **attracts** **and** aggregates **members** **of** **their** colony **to** **the** prospective **nest** site; **however**, **it** **also** **attracts** **workers** **from** **other** **nests**.

**If** **workers** **from** **two** **different** colonies **arrive** **at** **the** prospective **nest** **at** **the** **same** **time**, **they** may **fight** **for** **possession**. **Fights** may **be** escalated **into** protracted **battles**. **The** researchers **observed** **battles** **over** **a** **nest** **tree** **that** **lasted** **for** **two** **weeks**. **Each** **dawn**, **fifteen** **to** **thirty** **workers** **from** **two** **competing** colonies **arrived** **at** **the** contested **nest** site. **The** **workers** **from** **the** **two** colonies **faced** **off** **in** **two** swarms **and** displayed **and** **fought** **with** **each** **other**. **In** **the** displays, **pairs** **of** **bees** **faced** **each** **other**, slowly **flew** vertically **to** **a** **height** **of** **about** **three** meters, **and** **then** grappled **each** **other** **to** **the** **ground**. **When** **the** **two** **bees** **hit** **the** **ground**, **they** **separated**, **faced** **off**, **and** **performed** **another** aerial display. **Bees** **did** **not** **appear** **to** **be** **injured** **in** **these** **fights**, **which** **were** apparently ritualized. **The** **two** swarms **abandoned** **the** **battle** **at** **about** 8 **or** 9 **A**.M. **each** **morning**, **only** **to** **reform** **and** **begin** **again** **the** **next** **day** **just** after **dawn**. **While** **this** contest **over** an unoccupied **nest** site **produced** **no** **obvious** mortality, **fights** **over** occupied **nests** **sometimes** **kill** **over** 1,000 **bees** **in** **a** **single** **battle**.

count: 172

# Official 35-Passage 01 Seasonal Succession in Phytoplankton

Phytoplankton **are** **minute**, **free**-**floating** aquatic **plants**. **In** **addition** **to** **the** **marked** **changes** **in** abundance **observed** **in** phytoplankton **over** **the** **course** **of** **a** **year**, **there** **is** **also** **a** **marked** **change** **in** species **composition**. **This** **change** **in** **the** dominant species **from** **season** **to** **season** **is** **called** seasonal succession, **and** **it** **occurs** **in** **a** **wide** **variety** **of** locations. **Under** seasonal succession, **one** **or** **more** species dominate **the** phytoplankton **for** **a** shorter **or** longer **period** **of** **time** **and** **then** **are** **replaced** **by** **another** **set** **of** species. **This** **pattern** **is** **repeated** yearly. **This** succession **is** **different** **from** **typical** terrestrial ecological succession **in** **which** **various** **plants** **replace** **one** **another** **until** finally **a** **so**-**called** climax community **develops**, **which** persists **for** **many** **years**.

**What** **are** **the** factors **causing** **this** **phenomenon**? **Considering** **that** seasonal succession **is** **most** **often** **and** **clearly** **seen** **in** temperate **seas**, **which** **have** **a** **marked** **change** **in** **temperature** **during** **a** **year**, **temperature** **has** **been** **suggested** **as** **a** **cause**. **This** may **be** **one** **of** **the** factors, **but** **it** **is** unlikely **to** **be** **the** sole **cause** **because** **there** **are** species **that** **become** dominant species **at** **various** **temperatures**. Furthermore, **temperature** **changes** **rather** slowly **in** seawater, **and** **the** replacement **of** dominant species **often** **is** **much** **more** **rapid**.

**Another** **suggested** **reason** **is** **the** **change** **in** nutrient **level** **over** **the** **year**, **with** **differing** concentrations favoring **different** phytoplankton species. **While** **this** factor may **also** **contribute**, observations **suggest** **that** phytoplankton **populations** **rise** **and** **fall** **much** **more** quickly **than** nutrient concentrations **change**.

**Yet** **another** **explanation** **is** **that** species succession **is** **a** **consequence** **of** **changes** **in** seawater **brought** **about** **by** **the** phytoplankton **living** **in** **it**. **Each** species **of** phytoplankton secretes **or** excretes organic molecules **into** **the** seawater. **These** metabolites **can** **have** an **effect** **on** **the** organisms **living** **in** **the** seawater, **either** inhibiting **or** **promoting** **their** **growth**. **For** **any** individual organism, **the** **amount** **of** metabolite **secreted** **is** **small**. **But** **the** **effect** **of** secretions **by** **all** **the** individuals **of** **the** dominant species **can** **be** significant **both** **for** **themselves** **and** **for** **other** species.

**These** organic metabolites **could**, **and** **probably** **do**, **include** **a** **number** **of** **different** **classes** **of** organic compounds. **Some** **are** **likely** toxins, **such** **as** **those** released **by** **the** dinoflagellates (**a** species **of** plankton) **during** **red** tides, **which** inhibit **growth** **of** **other** photosynthetic organisms. **In** **such** **cases**, **the** **population** explosion **of** dinoflagellates **is** **so** **great** **that** **the** **water** **becomes** brownish **red** **in** color **from** **the** **billions** **of** dinoflagellate **cells**. **Although** **each** **cell** secretes **a** **minute** **amount** **of** toxin, **the** massive dinoflagellate **numbers** **cause** **the** toxin **to** **reach** concentrations **that** **kill** **many** **creatures**. **This** toxin **can** **be** **concentrated** **in** **such** filter-**feeding** organisms **as** clams **and** mussels, rendering **them** toxic **to** **humans**.

**Another** **class** **of** metabolite **is** **the** vitamins. **It** **is** **now** **known** **that** **certain** phytoplankton species **have** **requirements** **for** **certain** vitamins, **and** **that** **there** **are** considerable **differences** **among** species **as** **to** **requirements**. **The** B vitamins, **especially** vitamin B12, thiamine, **and** biotin, **seem** **to** **be** **the** **most** generally **required**. **Some** species may **be** **unable** **to** thrive **until** **a** **particular** vitamin, **or** **group** **of** vitamins, **is** **present** **in** **the** **water**. **These** vitamins **are** **produced** **only** **by** **another** species; hence, **a** succession **of** species **could** **occur** whereby **first** **the** vitamin-**producing** species **is** **present** **and** **then** **the** vitamin-**requiring** species **follows**.

**Other** organic compounds **that** may inhibit **or** **promote** **various** species **include** amino **acids**, carbohydrates, **and** fatty **acids**. **Although** **it** **is** **suspected** **that** **these** organic metabolites may **have** an **important** **role** **in** species succession **and** **it** **has** **been** demonstrated **in** **the** laboratory **that** phytoplankton species vary **both** **in** **their** **ability** **to** **produce** **necessary** vitamins **and** **in** **their** **requirements** **for** **such** **in** **order** **to** **grow**, **evidence** **is** **still** inadequate **as** **to** **their** **real** **role** **in** **the** **sea**.

**There** **is** **also** **evidence** **to** **suggest** **that** grazers (**animals** **that** **feed** **on** **plants** **or** stationary **animals**),particularly selective grazers, **can** **influence** **the** phytoplankton species **composition**. **Many** copepods (**small**, herbivorous crustaceans) **and** invertebrate larvae **pick** **out** **selected** phytoplankton species **from** **mixed** **groups**, **changing** **the** species **composition**.

**A** **growing** body **of** **evidence** **now** **suggests** **that** **all** **of** **the** factors **considered** **here** **are** **operating** simultaneously **to** **produce** species succession. **The** **importance** **of** **any** factor **will** vary **with** **the** **particular** phytoplankton species **and** **the** environmental **conditions**.

count: 172

# Official 28-Passage 01 Groundwater

**Most** **of** **the** **world**’s potable **water**—freshwater **suitable** **for** **drinking**—**is** **accounted** **for** **by** groundwater, **which** **is** **stored** **in** **the** pores **and** fractures **in** **rocks**. **There** **is** **more** **than** 50 **times** **as** **much** freshwater **stored** **underground** **than** **in** **all** **the** freshwater **rivers** **and** **lakes** **at** **the** **surface**. **Nearly** 50 **percent** **of** **all** groundwater **is** **stored** **in** **the** **upper** 1,000 meters **of** **Earth**. **At** greater **depths** **within** **Earth**, **the** **pressure** **of** **the** overlying **rock** **causes** pores **and** cracks **to** **close**, **reducing** **the** **space** **that** pore **water** **can** occupy, **and** **almost** **complete** closure **occurs** **at** **a** **depth** **of** **about** 10 kilometers. **The** greatest **water** **storage**, **therefore**, **lies** **near** **the** **surface**.

Groundwater **is** **stored** **in** **a** **variety** **of** **rock** **types**. **A** groundwater reservoir **from** **which** **water** **can** **be** extracted **is** **called** an aquifer. **We** **can** effectively **think** **of** an aquifer **as** **a** **deposit** **of** **water**. Extraction **of** **water** **depends** **on** **two** properties **of** **the** aquifer: porosity **and** permeability. **Between** sediment **materials** (**such** **as** **sand** **or** **small** **rocks**) **that** **are** **deposited** **by** **water**, **wind**, **or** glacial **ice** **grains** **are** **spaces** **that** **can** **be** **filled** **with** **water**. **This** pore **space** **is** **known** **as** porosity **and** **is** **expressed** **as** **a** **percentage** **of** **the** **total** **rock** volume. Porosity **is** **important** **for** **water**-**storage** capacity, **but** **for** **water** **to** **flow** **through** **rocks**, **the** pore **spaces** must **be** **connected**. **The** **ability** **of** **water**, **or** **other** fluids, **to** **flow** **through** **the** interconnected pore **spaces** **in** **rocks** **is** **termed** permeability. Fractures **and** joints **have** **very** **high** permeability. **In** **the** intergranular **spaces** **of** **rocks**, **however**, fluid must **flow** **around** **and** **between** **grains** **in** **a** tortuous **path**; **this** **winding** **path** **causes** **a** resistance **to** **flow**. **The** **rate** **at** **which** **the** **flowing** **water** **overcomes** **this** resistance **is** **related** **to** **the** permeability **of** **rock**.

Sediment **sorting** **and** compaction **influence** permeability **and** porosity. **The** **more** poorly **sorted** **or** **the** **more** tightly compacted **a** sediment **is**, **the** lower **its** porosity **and** permeability. Sedimentary **rocks**—**the** **most** **common** **rock** **type** **near** **the** **surface**—**are** **also** **the** **most** **common** reservoirs **for** **water** **because** **they** **contain** **the** **most** **space** **that** **can** **be** **filled** **with** **water**. Sandstones generally **make** **good** aquifers, **while** finer-**grained** mudstones **are** typically impermeable. Impermeable **rocks** **are** **referred** **to** **as** aquicludes. Igneous **and** metamorphic **rocks** **are** **more** compact, commonly crystalline, **and** rarely **contain** **spaces** **between** **grains**. **However**, **even** igneous **and** metamorphic **rocks** may **act** **as** groundwater reservoirs **if** extensive fracturing **occurs** **in** **such** **rocks** **and** **if** **the** fracture **system** **is** interconnected.

**The** **water** **table** **is** **the** **underground** **boundary** **below** **which** **all** **the** cracks **and** pores **are** **filled** **with** **water**. **In** **some** **cases**, **the** **water** **table** **reaches** **Earth**’s **surface**, **where** **it** **is** **expressed** **as** **rivers**, **lakes**, **and** marshes. Typically, **though**, **the** **water** **table** may **be** **tens** **or** **hundreds** **of** meters **below** **the** **surface**. **The** **water** **table** **is** **not** **flat** **but** **usually** **follows** **the** contours **of** **the** topographythe **shape** **of** **a** **surface** **such** **as** **Earth**’s, **including** **the** **rise** **and** **fall** **of** **such** features **as** **mountains** **and** **valleys** . **Above** **the** **water** **table** **is** **the** vadose **zone**, **through** **which** rainwater percolates. **Water** **in** **the** vadose **zone** drains **down** **to** **the** **water** **table**, **leaving** **behind** **a** **thin** **coating** **of** **water** **on** **mineral** **grains**. **The** vadose **zone** **supplies** **plant** **roots** **near** **the** **surface** **with** **water**.

**Because** **the** **surface** **of** **the** **water** **table** **is** **not** **flat** **but** **instead** **rises** **and** **falls** **with** topography, groundwater **is** **affected** **by** **gravity** **in** **the** **same** fashion **as** **surface** **water**. Groundwater **flows** downhill **to** topographic **lows**. **If** **the** **water** **table** intersects **the** **land** **surface**, groundwater **will** **flow** **out** **onto** **the** **surface** **at** **springs**, **either** **to** **be** **collected** **there** **or** **to** subsequently **flow** farther **along** **a** drainage. Groundwater commonly **collects** **in** **stream** drainages **but** may **remain** entirely **beneath** **the** **surface** **of** **dry** **stream**-**beds** **in** arid regions. **In** particularly **wet** **years**, **short** stretches **of** an **otherwise** **dry** **stream**-**bed** may **have** **flowing** **water** **because** **the** **water** **table** **rises** **to** intersect **the** **land** **surface**.

count: 165

# Official 18-Passage 03 Lightning

**Lightning** **is** **a** **brilliant** **flash** **of** **light** **produced** **by** an **electrical** discharge **from** **a** **storm** **cloud**. **The** **electrical** discharge **takes** **place** **when** **the** **attractive** **tension** **between** **a** region **of** negatively **charged** particles **and** **a** region **of** positively **charged** particles **becomes** **so** **great** **that** **the** **charged** particles suddenly **rush** **together**. **The** **coming** **together** **of** **the** oppositely **charged** particles neutralizes **the** **electrical** **tension** **and** releases **a** tremendous **amount** **of** energy, **which** **we** **see** **as** **lightning**. **The** **separation** **of** positively **and** negatively **charged** particles **takes** **place** **during** **the** **development** **of** **the** **storm** **cloud**.

**The** **separation** **of** **charged** particles **that** **forms** **in** **a** **storm** **cloud** **has** **a** **sandwich**-**like** structure. Concentrations **of** positively **charged** particles **develop** **at** **the** **top** **and** **bottom** **of** **the** **cloud**, **but** **the** **middle** region **becomes** negatively **charged**. **Recent** measurements **made** **in** **the** **field** **together** **with** laboratory simulations **offer** **a** **promising** **explanation** **of** **how** **this** structure **of** **charged** particles **forms**. **What** **happens** **is** **that** **small** (millimeter- **to** centimeter-**size**) pellets **of** **ice** **form** **in** **the** **cold** **upper** regions **of** **the** **cloud**. **When** **these** **ice** pellets **fall**, **some** **of** **them** **strike** **much** smaller **ice** crystals **in** **the** center **of** **the** **cloud**. **The** **temperature** **at** **the** center **of** **the** **cloud** **is** **about** -15˚C **or** lower. **At** **such** **temperatures**, **the** **collision** **between** **the** **ice** pellets **and** **the** **ice** crystals **causes** **electrical** **charges** **to** shift **so** **that** **the** **ice** pellets **acquire** **a** negative **charge** **and** **the** **ice** crystals **become** positively **charged**. **Then** updraft **wind** currents **carry** **the** **light**, positively **charged** **ice** crystals **up** **to** **the** **top** **of** **the** **cloud**. **The** heavier, negatively **charged** **ice** pellets **are** **left** **to** **concentrate** **in** **the** center. **This** **process** **explains** **why** **the** **top** **of** **the** **cloud** **becomes** positively **charged**, **while** **the** center **becomes** negatively **charged**. **The** negatively **charged** region **is** **large**: **several** **hundred** meters **thick** **and** **several** kilometers **in** diameter. **Below** **this** **large**, **cold**, negatively **charged** region, **the** **cloud** **is** warmer **than** -15˚C, **and** **at** **these** **temperatures**, **collisions** **between** **ice** crystals **and** **falling** **ice** pellets **produce** positively **charged** **ice** pellets **that** **then** populate **a** **small** region **at** **the** **base** **of** **the** **cloud**.

**Most** **lightning** **takes** **place** **within** **a** **cloud** **when** **the** **charge** **separation** **within** **the** **cloud** collapses. **However**, **as** **the** **storm** **cloud** **develops**, **the** **ground** **beneath** **the** **cloud** **becomes** positively **charged** **and** **lightning** **can** **take** **place** **in** **the** **form** **of** an **electrical** discharge **between** **the** negative **charge** **of** **the** **cloud** **and** **the** positively **charged** **ground**. **Lightning** **that** **strikes** **the** **ground** **is** **the** **most** **likely** **to** **be** destructive, **so** **even** **though** **it** **represents** **only** 20 **percent** **of** **all** **lightning**, **it** **has** **received** **a** **lot** **of** **scientific** **attention**.

**Using** **high**-**speed** photography, **scientists** **have** **determined** **that** **there** **are** **two** **steps** **to** **the** occurrence **of** **lightning** **from** **a** **cloud** **to** **the** **ground**. **First**, **a** **channel**, **or** **path**, **is** **formed** **that** **connects** **the** **cloud** **and** **the** **ground**. **Then** **a** **strong** current **of** electrons **follows** **that** **path** **from** **the** **cloud** **to** **the** **ground**, **and** **it** **is** **that** current **that** illuminates **the** **channel** **as** **the** **lightning** **we** **see**.

**The** formation **of** **the** **channel** **is** initiated **when** electrons surge **from** **the** **cloud** **base** **toward** **the** **ground**. **When** **a** **stream** **of** **these** negatively **charged** electrons **comes** **within** 100 meters **of** **the** **ground**, **it** **is** **met** **by** **a** **stream** **of** positively **charged** particles **that** **comes** **up** **from** **the** **ground**. **When** **the** negatively **and** positively **charged** **streams** **meet**, **a** **complete** **channel** **connecting** **the** **cloud** **and** **the** **ground** **is** **formed**. **The** **channel** **is** **only** **a** **few** centimeters **in** diameter, **but** **that** **is** **wide** **enough** **for** electrons **to** **follow** **the** **channel** **to** **the** **ground** **in** **the** visible **form** **of** **a** **flash** **of** **lightning**. **The** **stream** **of** positive particles **that** **meets** **the** surge **of** electrons **from** **the** **cloud** **often** **arises** **from** **a** **tall**, **pointed** structure **such** **as** **a** **metal** flagpole **or** **a** **tower**. **That** **is** **why** **the** subsequent **lightning** **that** **follows** **the** **completed** **channel** **often** **strikes** **a** **tall** structure.

**Once** **a** **channel** **has** **been** **formed**, **it** **is** **usually** **used** **by** **several** **lightning** discharges, **each** **of** **them** **consisting** **of** **a** **stream** **of** electrons **from** **the** **cloud** **meeting** **a** **stream** **of** positive particles **along** **the** established **path**. **Sometimes**, **however**, **a** **stream** **of** electrons **following** an established **channel** **is** **met** **by** **a** positive **stream** **making** **a** **new** **path** **up** **from** **the** **ground**. **The** **result** **is** **a** **forked** **lightning** **that** **strikes** **the** **ground** **in** **two** **places**.

count: 156