

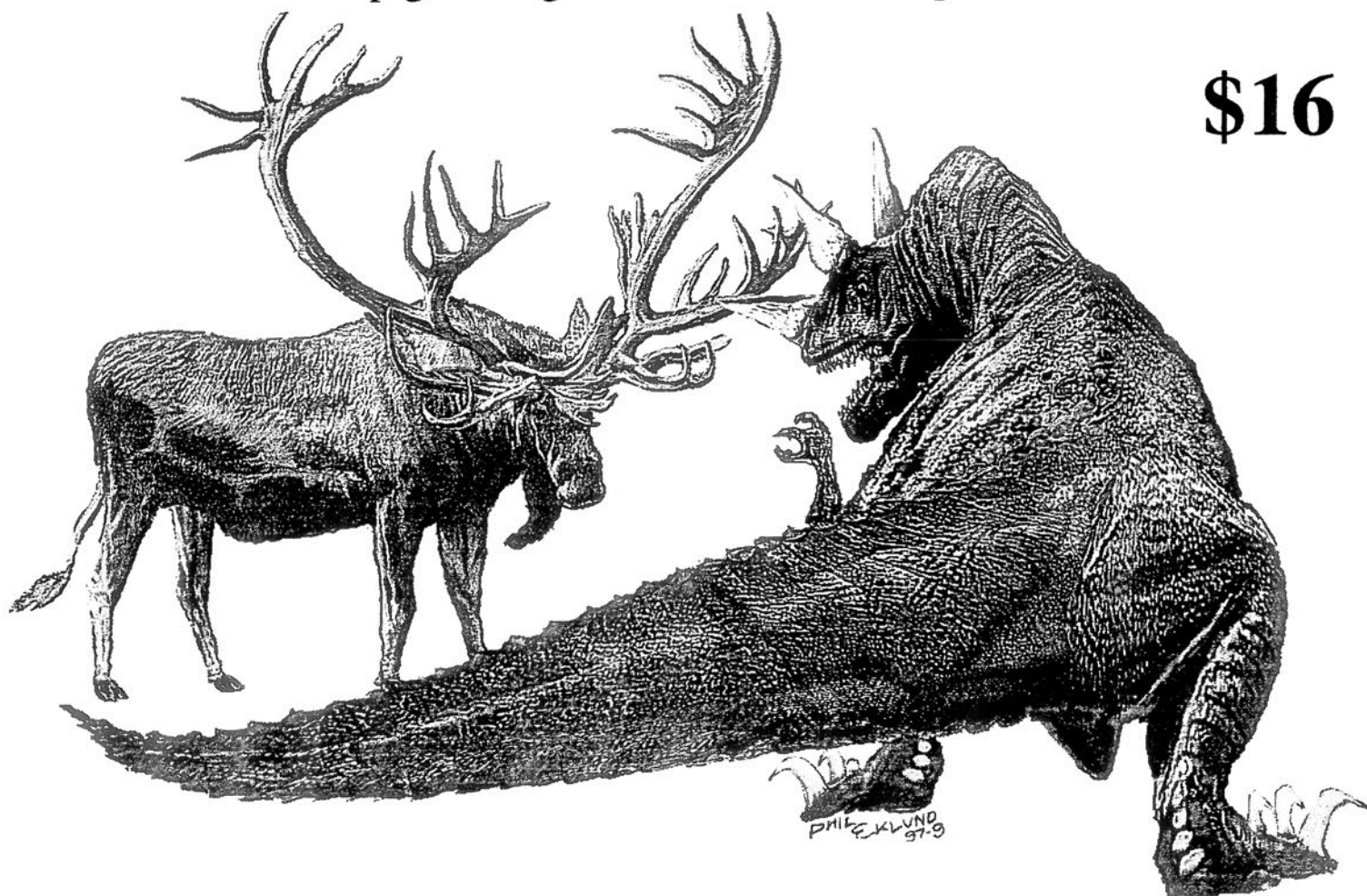


American Megafauna™



A quarter of a billion years ago, in what is now America, two animals evolved at the same time: Proto-dinosaurs and proto-mammals. Would you believe feathered flying pigs eating herbivorous velociraptors?

\$16



Description:

- One to four players evolve their own prehistoric animals.
- Introductory, Basic, Advanced, and Solitaire Game rules.
- Objective: Dominate America, drive other animals extinct.

Scale: 5 million years per turn, 1500 km per hex,
30 megatons of biomass per herbivore counter.

Components: Rulesbook, 22 X 17 Mapsheet, Four Physiology Sheets,
Timeline, 189 Cards, 323 Counters.

Complexity: Moderate. Setup in 10 minutes; play within 4 hours.



**SIERRA MADRE
GAMES CO.**

SMG20



American Megafauna



The Continuing Evolutionary Contest between Dinosaurs and Mammals

SMG 20

REV [September 22, 1997]

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1.0 Overview

1.1 AMERICAN HISTORY



type requires one M (maritime DNA) and two A (armor-crunching DNA) to eat the oysters.

On the super-continent of **Pangea**, a quarter of a billion years ago, an unknown catastrophe wipes out 96% of the animals. In the corner of Pangea that will be known as America, small survivors cautiously sniff the post-holocaust air at the dawn of the Mesozoic Era. These creatures are of two dynasties: proto-dinosaurs (ruling reptiles) and proto-mammals. The victor in this titanic eco-niche competition will determine the masters of the Mesozoic.

Clearly, the dinosaurs triumphed that day, 248 million years ago, and ruled the Earth for 170 million years. Only to be overthrown, in what must be the upset of the eon, by the mammals. Yet the contest is not over.

1.2 INTRO & BASIC GAMES

1.2.1 INTRODUCTORY GAME It is suggested that the Introductory Game ("Birds vs. Marsupials", see backs of display sheets) be read and played before attempting to read these Basic Game or Advanced Game (see 6.0) rules.

- Solitaire Game rules are included on a separate sheet.

1.2.2 MEGADYNASTY *American Megafauna* is a game for one to four players. In the Basic Game, each player decides which of two megadynasties to play:

- Ruling reptile (archosaur, i.e., crocodiles, dinosaurs, birds)
- Mammal megadynasty.

1.2.3 COURSE OF PLAY Players start as one of four nondescript **archetypes** (see glossary for definition of words in bold), but can branch out new species from this basic type by bidding on **genotype** cards as they are revealed. For auction "currency", players use gene coins from a "gene pool". The dinosaur players may bid upon anything from mutated brontosaurus to birds, and the mammal side may evolve pigs, hippos, and elephants. These animal types are called **genotypes**. Their populations are represented by counters on the map.

1.2.4 EVOLUTION As ecological conditions change in America, the animals must either migrate, adapt, or go extinct. **Migration** means moving on the map to reach a more clement **biome**. Adapting means bidding on DNA cards to add to a genotype's repertoire. For instance, a browsing pig might buy a "gizzard stone" DNA card so it can eat the grasses that now dominate its area.

1.2.5 ENVIRONMENT The map is populated by **biome** cards, each listing a habitat and its DNA requirements for its exploitation. For instance, an oyster bed biome requires "MAA" DNA, which means a geno-

1.2.6 VICTORY Each turn is started by revealing an epoch card. When the cards are gone, the player with the most population counters on the map wins.

1.2.7 GAME SCALE Each epoch card represents 5 million years (half a megadeade). The standard game takes 260 million years, the amount of time it takes the solar system to orbit once about the center of the Milky Way (known as a gal-year). Each hex represents a physiographic region 1500 km across.

- See glossary entry biomass for more game scale.

2.0 Components

2.1 COMPONENTS LIST

- 1 Mapsheet
- 1 Rulesbook
- 189 Cards of two colors
- 323 Counters of two colors
- 4 Physiology / Intro Game sheets
- 1 Timeline / Game Tips sheet



This is a dice-less game; a die is not required.

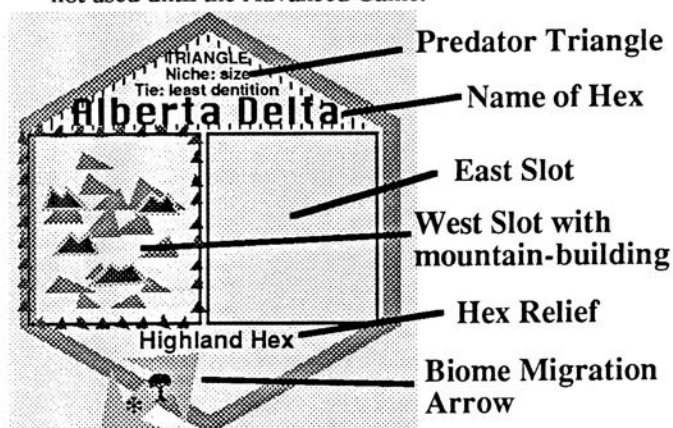
To represent the gene pool, about 25 pennies or washers per player are recommended. The map comes in two pieces, which should be trimmed and taped together. Counters must be cut apart; scissors are recommended.

2.2 MAPSHEET

2.2.1 HISTORICAL BOUNDARIES The mapsheet represents the North American continent as it has appeared a quarter eon ago (the Triassic), in the northwest corner of the supercontinent **Pangea**. What is now the American East coast is separated by high mountains (the Hercynians) from Africa, South America, and Eurasia. An ocean subduction zone is splitting these continents off, and by the Jurassic Period this rift will fill with seawater and become the Atlantic Ocean. Some of the ancient coastlines as sea levels rose and fell are suggested on the map.

2.2.2 TRIASSIC AMERICA Much of Western America is dry sand dunes, shadowed from the easterly winds desiccated by passage over the Hercynian mountains. Eastern America, however, is lush and verdant with rainforests, all the way north to Greenland, which actually lives up to its name. An arm of the Great Tethys Ocean (see **Zechstein Sea** in the glossary) reaches the area where present day Spain and Maine are melded together. Another shallow sea, the Epeiric, resides in the center of America. Salt deposits today mark where this sea repeatedly dried up in the arid conditions.

2.2.3 HEXES The map is divided into 11 named hexes. Hexes are labeled either "highland" or "lowland"; the latter are subject to periodic inundations. The arrows between the hexes represent biome migration directions, not used until the Advanced Game.



2.2.4 SLOTS & PREDATOR TRIANGLE Each hex has two slots (card-sized rectangles). Biome cards are stored in either the East or the West slots, as shown above. The triangle-shaped area at the top of each hex, just above the slots and containing the title of the hex, is called the "predator triangle".

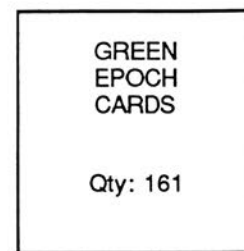
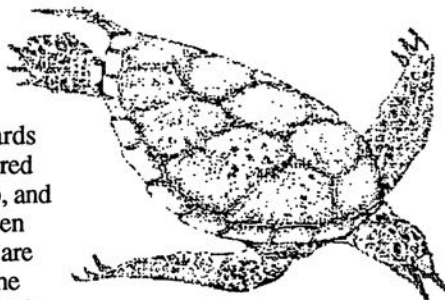
2.2.5 MOUNTAIN BUILDING SLOTS Certain slots are marked by triangular mountain symbols (see the west slot in the diagram above). These are slots where mountains can grow, if an **Orogeny** biome card comes up. See 5.1.4.

2.2.6 LATITUDE The map has four latitudes (hex row), labeled "arctic circle", "jet stream", "horse latitudes", and "tropical". For instance, the two northernmost map hexes ("Beringia" & "Greenland") are in the Arctic Circle latitude. The southernmost latitude, "tropical", has three hexes (Sierra Madre, Gulf of Mexico, and Panama).

2.2.7 BIOME HOLDING ZONES (Advanced Game Only) The map has eight rectangles that are not within hexes, such as Asia, Europe and Spain. In the Advanced Game, these "holding zones" hold biome cards that migrate off the map. Some holding zones, separated from America by "bridges", store **immigrants** that are waiting to emigrate into America.

2.3 CARDS

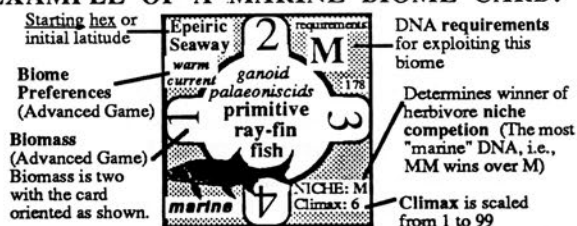
2.3.1 COMMENTARY Cards are either red or green, the red cards are used during setup, and the far more numerous green cards (called Epoch Cards) are shuffled and placed upon the time track, and drawn throughout the game.



Whether green or red, cards are one of five types: **biome**, **genotype**, **DNA**, **immigrant**, or **catastrophe**.

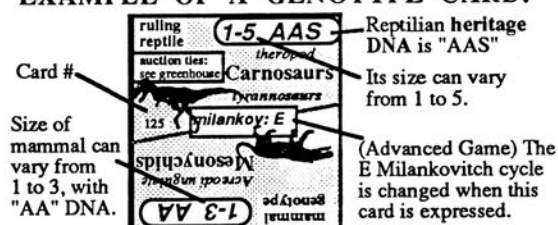
2.3.2 BIOME CARDS These cards specify the environment type of a particular habitat, including vegetation, marine life, glaciers, and mountains. A biome card, as shown below, encodes its **requirements** (the minimum DNA a player's genotype needs to exploit the resource), its **niche** (determines which genotype wins if more than one is competing for the same resource), and its **climax**. (The higher the climax, the more durable and advanced the resource is.)

EXAMPLE OF A MARINE BIOME CARD:



2.3.3 GENOTYPE CARDS Genotype cards specify a particular animal type (order or suborder), plus some of its innate characteristics (called "heritage DNA"). Notice that genotype cards have two sides. If held by a dinosaur player, the ruling reptile orientation is used, the Carnosaur in the example below. But if the card is acquired by the mammal player, the Mesonychid side is used.

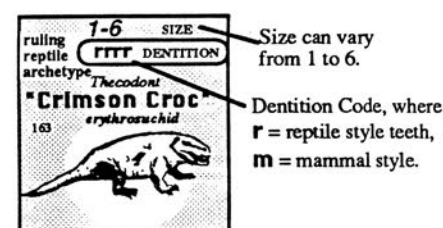
EXAMPLE OF A GENOTYPE CARD:



HISTORICAL NOTE: If the animal picture is silhouetted on the Genotype card, then that animal order is extinct today.

EXAMPLE OF AN ARCHETYPE GENOTYPE CARD:

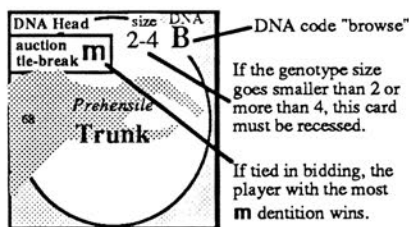
Each player starts with one of four special genotype cards called the **archetype**. Shown is an archetype from the "ruling reptile" dynasty.



2.3.4 DNA CARDS These are the allele genetics of animal characteristics, used to evolve a genotype or **archetype** during the game.

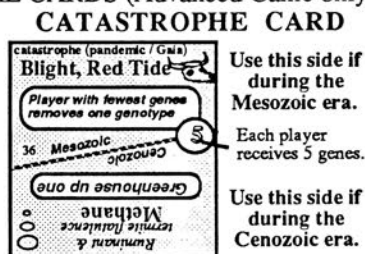
EXAMPLE OF A DNA HEAD CARD:

DNA cards come in three locations: head, guts, and limbs. Shown is a head DNA card which grows a pachyderm-style trunk on the animal.



2.3.5 CATASTROPHE CARDS (Advanced Game only)

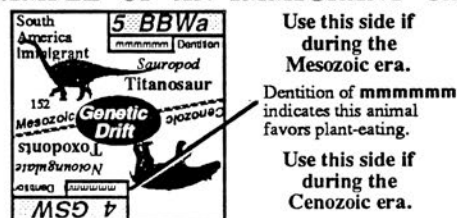
These cards simulate a terrestrial or extra-terrestrial event that players have no control over, such as diseases or weather effects.



2.3.6 IMMIGRANT CARDS (Advanced Game only)

These cards represent non-player controlled animals invading from Asia, South America, or the Atlantic Ocean. This card also has two sides, depending upon whether the timeline shows that the game turn is during the Mesozoic or Cenozoic era, see 2.4.3.

EXAMPLE OF AN IMMIGRANT CARD:



2.4 PHYSIOLOGY SHEETS & TIMELINE

2.4.1 DENTITION Each Physiology sheet has its **archetype** and **dentition** (tooth pattern) listed, where **m** = mammal-style teeth, and **r** = reptile-style teeth.

The four archetypes, and their dentition, are listed below:

- Dog-face (cynodont) **mmm** proto-mammal
- Two-Tusker (dicynodont) **mmrrr** proto-mammal
- Rabbit Croc (ornithosuchid) **rm** ruling reptile
- Crimson Croc (erythrosuchid) **rrrr** ruling reptile

Notice that the Dog-face has the most mammal-type dentition, then the Two-tusker, Rabbit croc, and Crimson croc. The Crimson croc has no mammal teeth at all, but has the most reptile teeth (**rrrr**).

2.4.2 SIZE TRACK The position of the genotype card in this track records the size of adult individuals in the population (from 40 kg to 60 tons).

2.4.3 TIMELINE Each card played from the timeline represents an epoch (one game turn). After 19 epochs, as shown on the timeline, the era changes from the Mesozoic to the Cenozoic.



2.5 COUNTERS

2.5.1 POPULATION COUNTERS & DENTITION

Counters represent each player's population. Up to four players are accommodated, and each of their counters is distinguished by their dentition (either **rm**, **mmm**, **rrrr**, or **mmrrr**, see 2.4.1). Each player has 14 triangular population counters, and 13 times 3 square ones.

2.5.2 GENOTYPES Each player has four different kinds of population counters, each with the same **dentition**, but each with a different picture representing a different order of animal. These four populations are called a player's **genotypes**, and are displayed in four columns on the Physiology sheet. One of the four is the **archetype** genotype; these have triangular counters.

NOTE: These four genotypes can be thought of as four different species, if one wishes, but the level of detail in this game really only gets down to the order or suborder level. Thus, each population counter represents an entire assemblage of related species, at 30 megatons of biomass each.

2.5.3 DNA COUNTERS Players use DNA counters to indicate added features or specializations that their genotypes have, see 5.2.4. Each DNA counter is coded with a single letter, deciphered as follows:



- A = armor piercing or a = armored (see 5.6.1),
- B = browse (ability to eat trees, 7.2.9),
- G = graze (ability to digest grass & shrubs, see 7.2.10),
- H = husker (ability to shell husks, Advanced Game 6.6.2),
- I = insect-eating ability (see 7.2.6),
- M = marine (swimming adaptations),
- N = nocturnal (burrowing or nighttime senses),
- P = physiology (behavior and climate adaptations),
- S = swiftness (see 5.7.5),
- W is wild (player choice, see 5.2.6), and
- sex = sexual intimidation or advertising (see 5.2.7).

3.0 Game Set Up

3.1 NUMBER OF PLAYERS

3.1.1 NUMBER OF PLAYERS From two to four players can play. Each player is given one of the four Physiology sheets at random, or may choose his favorite if all agree.

- These sheets have a depiction of the player's **archetype**, from either the "proto-mammal" or the "ruling reptile" clans.
- Players find the Red card with their animal depiction and put it on their number one size slot.

3.1.2 CLASSROOM GAME Students are divided into teams; each team has one genotype. As each archetype speciates into new forms, individual students or small student teams are given control of these orders.

- Permission is granted to photocopy additional Physiology sheets for classroom use. Smaller copies of the map are available from Sierra Madre Games for classroom use, so that each team may have their own map.

3.2 TIMELINE SETUP



3.2.1 EPOCH CARDS These cards are green in color and include **DNA**, **biome**, **genotype**, **catastrophe**, and **immigrant** cards that are revealed randomly during a game.

- Thoroughly shuffle the green (epoch) cards and place 51 of them on the time track sheet as directed (37 of them in the Mesozoic Era, and 14 of them in the Cenozoic Era). The 110 remaining epoch cards are not used.

3.3 MAP SETUP

3.3.1 MAP SETUP There are eleven map hexes, each with its own name. Red biome cards are placed in each hex, as per the listing on upper left of each card. The starting biome cards are marked either east or west side of the hex. Most hexes have two biome cards, placed side by side, face up, oriented so that the number "2" is on the "north" side of the card. When done, all but two slots (in Panama and Beringia) should be filled.

3.3.2 INITIAL GENOTYPE COUNTER PLACEMENT Each player places one triangular population counter (his **archetype**), on the biome card of his choice. It must be a card with requirements of "none". Players set up in order of **r** dentition, so that **rrrr** goes first, then **mmrrr**, then **rm**, then **mmm**.

NOTE: See *Permian Extinctions* for more on why the reptiles set up first.

3.3.3 GREENHOUSE & MILANKOVITCH CYCLE (ADVANCED GAME) Place a coin in the "300 ppm start" position in the "Greenhouse Level" map track. Place a coin in each of the three "Milankovitch Cycle" tracks, in the circles labeled "start".

- All of the bridges start open & unflooded, with no coins.

3.3.4 ICE-SHEETS (ADVANCED GAME) Unless playing the Advanced Game, the four ice-sheet biome cards are not used. Otherwise, put an ice-sheet biome in one of each of these holding zones: Kolyma, Angaraland, Baltica, and Europe.

3.4 GENE STOCK

3.4.1 A pile of coins, washers or counters represents the game's gene pool, where each coin represents an **allele** of DNA.



3.4.2 PLAYER'S STARTING GENE COINS All players start the game with five gene coins.

- Players' coins are stored on their Physiology sheets, and are used to purchase genotype or DNA cards per 5.1.2.

3.5 LATE ARRIVALS

3.5.1 Late arrivals get an unused Physiology sheet and its **archetype** card per 3.1.1 and are paid their 5 genes.

- They may use these genes to purchase, for one gene, any DNA or genotype cards in the discard pile at this time.

3.6 EARLY DEPARTURES

3.6.1 If a player leaves, his population counters remain in place, and defend normally in **niche competition**.

3.6.2 If a player's last genotype dies, he may still collect genes and play on. (But if only one player has population left, see 6.8.2.) A remnant inconspicuous population is assumed, and his hand size is zero cards.

- If such a player purchases a new genotype, he may place a single counter anywhere on the map.
- Players with genes but no population must pay one gene at the beginning of every turn to represent genetic drift.

OPTIONAL: Players with no population only are eligible to bid on **immigrant** cards and use them as genotypes for new population counters. If bought, immigrant counters are still placed per 2.3.6 and 6.5.2 and use dentition per 6.5.3, but are otherwise subsequently treated as a genotype using the standard migration, population expansion, etc. rules. "Immigrant" players are barred from bidding on further genotype or immigrant cards, and are limited to a population of 14.

4.0 Play Sequence

- **COMMENTARY** Each *American Megafauna* game turn is five million years long (half a megadeade), beginning with the end of the Permian 245 million years ago. Each turn (called an epoch) is divided into a set of seven activities, known as Periods, listed below. Within each period, the player with the most **m** dentition goes first, followed by the next most, etc.

THE SEVEN PERIODS IN EACH EPOCH

4.1 REVEAL & AUCTION CARD An epoch card is revealed. If it is a DNA or genotype card, it is auctioned and added to the winner's hand. If it is a biome card, it is played upon the map, per 5.1.4, and each player is awarded one gene. If it is a catastrophe card, each player is awarded 5 genes. <u>Advanced Game:</u> Catastrophe & immigrant cards have added effects.
4.2 EXPRESS CARDS Each player may express cards from their hand, or recess cards from their sheet. DNA counters are placed upon genotype cards. <u>Advanced Game:</u> Milankovitch cycles are adjusted upon being expressed.
4.3 TROPHIC LEVEL, SIZE, & HAND ADJUST Each player positions his counters to be either herbivores or carnivores, and adjusts their size up to one step. If the number of cards in a hand is greater than the number of genotypes of a player, then the extra cards are discarded.
4.4 POPULATION EXPANSION Each player increases its population by one in every biome occupied by its genotype counters. Each player increases its predator population by one in each hex he has predators.
4.5 HERBIVORE MIGRATIONS Move counters per 5.5.
4.6 CARNIVORE MIGRATIONS & FINAL SIZE Each player moves predator counters per 5.6, and adjusts their size.
4.7 EXTINCTIONS Each player removes unsupported population per 5.7.1. Losers in niche competitions also remove counters. Genotypes with no population have their genotype card discarded, along with any DNA counters upon it or exclusive DNA cards.

NOTE: A hex by hex check for biomass, biome & prey suitability, and predator/prey size is suggested to correct any illegal populations. Any DNA found to be outside its size range is immediately recessed.

5.0 The Periods

COMMENTARY (ORDER) The following seven Periods are accomplished every epoch (turn). The player with the most mammal **dentition** (2.4.1) goes first within each Period. In a stable ecology, if all agree, Periods 2 through 7 can be skipped.

5.1 REVEAL EPOCH CARD

5.1.1 COMMENTARY The next epoch card is turned over. If it is a **genotype** or **DNA** card, it is auctioned to the highest bidding player per 5.1.2. If it is a **biome**, place per 5.1.3, and award each player a gene from the gene pool. If it is a **catastrophe**, each player is awarded five gene coins. Ignore **immigrant** cards (unless playing the Advanced Game, then see 6.5).

- The first epoch card revealed is the top card of the eight in the Triassic Period on the timeline.
- A player receives twice as many gene coins if he has any **sex cards** expressed (i.e., on his sheet) per 5.2.7.
- (Advanced Game) If a catastrophe card comes up, see 6.2, and if an immigrant card comes up, see 6.5.

5.1.2 AUCTION Each player interested in buying the revealed **genotype** or **DNA** card puts a gene coin on it. If more than one player puts a coin on it, players may increase their bid freely. The auction is over when no player is willing or able to bid higher.

- Losers get their bids back. Winners obtain the card, which go into their hand (placed face up or face down just off their Physiology sheet).
- If no player puts any genes on a card, it goes into a discard pile.
- Biome, catastrophe, and immigrant cards are not auctioned.
- Players may NOT buy, sell, loan, exchange, or donate their cards or genes to other players.

5.1.3 AUCTION TIE-BREAKERS In situations where two or more players have bid exactly the same number of gene coins on a card, then refer to the following:

- Genotype Cards. If tied, the winning bidder (during the Cenozoic Era) is the player with the most reptile **dentition** (i.e., **rm** beats **mmm**). During the Mesozoic era, the player with the most mammal dentition (2.4.1) wins ties.
- Genotype Cards (Advanced Game). If the Greenhouse Level (see map table) is 300 ppm or higher, then the player with the most reptile dentition wins bidding ties for Genotype cards (**mmrrr** beats **rm**). But if it is 200 ppm or less, then the most mammal dentition wins ties.
- DNA Cards. If tied, the bidder with the highest dentition specified on the upper left corner of that DNA card buys it.

EXAMPLE: If the "Trunk" card is bid upon, (which is labeled "auction tie-break: **m**", see 2.3.4), then the **rm** player would win over the **rrrr** player if each bid only one gene. This reflects an advantage mammals have in obtaining trunks.

5.1.4 BIOME CARD PLACEMENT If a biome card is revealed, then the following procedure is used to discover which hex the new biome goes into. Biomes are put into a hex of the latitude (see 2.2.6) or relief (see below) specified in the upper left corner of its card. All hex slots in this latitude are examined to see which contains the **lowest climax** biome card, (see 2.3.2), and the new biome card replaces or displaces (5.1.5) this card.

- Empty slots. These count as zero climax, and biome cards are placed into the first empty slot, starting with the farthest south, and reading left to right (west to east). In the Advanced Game, slots in the same hex as a biome of biomass 4 are considered to be crowded out and do not exist.
- Extinction. If all available slots are filled with cards with greater climax, the biome goes extinct.
- Stacking. Only one biome card per slot (two per hex).
- Relief. All marine biomes are restricted one of the four hexes of "lowland" relief (see 2.2.3). "**Orogeny**" biomes are restricted to one of the five slots with the "mountain-building" symbols in them (see 2.2.5).
- Any latitude. Some "cosmopolitan" biomes (like the grasses) are unrestricted as to latitude or relief. These can inhabit any hex on the map.
- Biomass. Biomes are placed at biomass 2. In the Advanced Game, Biomes are placed at the same biomass as the biome they are replacing, or if they go into an empty slot, are placed at that slot's capacity.

5.1.5 DISPLACEMENT OF BIOMES If a biome replaces a lower-climax biome in a slot, the original biome is displaced north or south one hex, if an empty slot is available in its hex or an adjacent hex. Displaced biomes favor southerly and westerly slots, if more than one empty is available.

- Marine biomes cannot be displaced into highland hexes.
- In the Basic Game, displaced **orogeny** biomes go extinct.
- If no empty slots are adjacent, then the "bumped" biome goes extinct.
- (Advanced Game). If biomes have a preference for wet or dry per 6.4.1, they adjust **biomass** for moisture tolerance upon displacement or migration, but not upon initial placement.

5.1.6 RAIN-SHADOW CARD One red biome card, the "rain-shadow sand dunes" card, migrates whenever a new mountain range is formed, reflecting the ability of freshly-formed mountains to block rainfall from reaching the interior of a continent.

- Whenever an **orogeny** biome appears on the map, the **rain-shadow** card is moved into the other slot in its hex. It may have to be "resurrected" from the discard pile if necessary to do this.
- The rain-shadow displaces (see 5.1.5) any lower climax card already there, if any.

5.2 EXPRESS CARDS

5.2.1 COMMENTARY Player-held cards (genotype or DNA) can be "expressed" (face-up and in-play on their Physiology sheet), or "recessed" (held in their hand).

5.2.2 EXPRESS CARDS All players, beginning with the one with the most **m dentition**, may express any or all **genotype** or **DNA** cards from their hand to their Physiology sheet.

5.2.3 EXPRESS GENOTYPE CARDS These cards are expressed by placing them on the desired size of the Physiology sheet size track. Players must use the side specified in 2.3.3. This represents speciating (branching) a new animal form of their megadynasty.

- **Parentage.** Players choose one of their existing genotypes for this new one to evolve from. They then select a new genotype counter type (from the four available), and swap one of the existing population counters on the map with this freshly-evolved variant.
- **Counter Placement.** Players must decide which of their counters on the map is changed to the new genotype counter. The swapped counter must be of the genotype that the new genotype is evolving from.
- **Place a population counter of the chosen icon on the genotype card to show what population it represents.** Do not do this if a player runs out of population counters.
- **Heritage.** The new genotype is entitled to all the **DNA** counters (2.5.3) that the genotype it evolved from had, so select new **DNA** counters until the new genotype has all the **DNA** that its "parent" has (except for those outside the **DNA**'s size range). However, **heritage DNA** (2.3.3) of the parent is not inheritable, only the **DNA** counters. **Recessive cards** (5.2.5) and cards/counters which are incompatible with the new genotype's heritage are also not inheritable.
- (Advanced Game). Some **DNA** cards have special abilities, these abilities are not inheritable (except for flight or sex).
- **Genotype Replacement.** Players may only express four genotypes (including their archetype) at a time. Players must recess one of their four extant genotypes to express a fifth genotype. All population counters of the superseded genotype are removed, except for the one counter that becomes the new superseding genotype. This represents an animal order evolving directly into another, and inherits **DNA** per previous bullet.
- **Milankovitch Cycles** (Advanced Game). Players expressing a genotype card trigger a change in the Earth's orbit per 6.1.

5.2.4 EXPRESS DNA CARDS A player may add to the characteristics and abilities of a genotype by expressing a **DNA** card. If he has more than one genotype in the size track, then he must choose one and put the **DNA** card in the column corresponding with that genotype counter.

- If a **DNA** card is expressed, then **DNA** counters of the letters specified may be placed upon the genotype card as a reminder.

EXAMPLE: If a player decides to give his stegosaurus feathers, (which are "PP"), then two "P" counters may be placed upon that genotype card on the size track.

- **DNA** Cards may only be expressed if the genotype is within the size range listed on the **DNA** card.

EXAMPLE: If the stegosaurus are at size five, they may not get feathers, which have a 1-4 size range.

- **DNA** cards are of three types: Head, Guts, and Limbs. The archetype may only express a maximum of two **DNA** cards from each of these three types. The other genotypes may only express one from each type. These limitations are shown by the number of slots on the Physiology sheet.

NOTE: DNA inherited from one's ancestor does not count towards this one DNA card limit on each type. For instance, if a genotype diverges from an archetype with both a trunk (B) and saber teeth (A), then it receives a B and an A counter for both of these two head DNA. This genotype still has an empty head slot, which it can fill with a head DNA card of its own, like an anteater tongue.

- The "wings" **DNA** card uses its own counter, which gives special abilities [5.5.1, 5.5.5, 5.5.6] and is inheritable.

5.2.5 RECESS CARDS Players may withdraw **DNA** Cards from their Physiology sheet to their hand. (Genotype cards may only be recessed per the sixth bullet of 5.2.3.) This removes associated **DNA** counters from all genotypes using the card.

- If a recessed **DNA** card is re-expressed, it may be applied to only one genotype of the player's choice per 5.2.4.
- **Forced Recession.** Some **DNA** cards contain a statement that if they are expressed, they recess other **DNA** cards that genotype may have. (Other genotypes of a player are unaffected.) Recessed cards are returned to one's hand, and the associated **DNA** counters (on the genotype card) are removed. If the number of recessed cards exceeds the maximum (5.3.4), the player may choose which to express or discard.
- **DNA** Cards may not be expressed which would recess innate qualities (**heritage DNA**) of the genotype played upon.

EXAMPLE: The "Saber Tooth" DNA card carries the legend "recesses all G cards, cannot be used with G heritage". So it cannot be expressed on genotypes (such as duckbills or camels) that have "G" heritage.

5.2.6 WILD CARD DNA The primate, forebrain, and tool-use cards have the "W" **DNA** code. At any time after they are expressed, the player puts the **DNA** counter of his choice upon his genotype card.

- Once selected, this **DNA** is fixed.
- **Tool-use card** (using rocks, spines, or other implements) requires one of the following cards to be expressed in a genotype: biped, forebrain, tripod, thumb spike, or trunk.
- **Technology DNA.** This card has double W **DNA** and cannot be expressed unless the Tool-use card (see preceding paragraph) is expressed first. Players can change both "wild" **DNA** tech counters during their size adjust/trophic change period.

5.2.7 SEX DNA Sex cards are a special type of head **DNA**, representing sophisticated sexual behavior. (And you thought this game would be boring!) A player doubles the number of genes he receives (from revealed biome & catastrophe cards) if one or more of his surviving genotypes have a sex gene.

- A "sex" counter is placed upon the genotype card, and this is inheritable per 5.2.3.
- There is no advantage to having more than one sex card.

5.3 ADJUST TROPHIC LEVEL, SIZE, & HAND



5.3.1 ORDER OF PLAY The player with the most **r** dentition adjusts the size and **trophic level** of his genotypes first. Then the player with the next highest **r** dentition adjusts his sizes and trophic levels, etc.

5.3.2 SIZE ADJUST Each player changes the size of their animals by one bigger or smaller, if he wishes. This is done by moving the genotype card one space on the size track and announcing this change out loud. This evolves the adult size of individuals in all population counters of that genotype.

- Genotypes are not allowed to change into a size outside the range specified on its genotype or archetype card.
- If the size change of a genotype is outside the size range of any of its DNA cards, those DNA counters are removed from the genotype. If no other genotypes are using a DNA card, it must be recessed by returning it to one's hand (5.2.5).

5.3.3 TROPHIC LEVEL Genotypes may be either plant-eaters or meat-eaters, as shown by the position of their counters in the hex. If the counters are on top of a biome card, they are plant-eating herbivores. If the counter is in the hex, but not on top of a card (instead being within the "**predator triangle**", see 2.2.3), then it is a meat-eater.

NOTE: Some of the biome cards are insects or seafood, but insect eaters and seafood-eaters are treated the same as plant-eaters in this game.

NOTE: Herbivores suffer no ill effects from being preyed upon, except per 5.7.3.



5.3.4 TROPHIC LEVEL ADJUST Players may change the **trophic level** from herbivore to carnivore, or vice versa, if they wish, by changing the location of the population counters within a map hex during this period.

- If a herbivore counter decides to change into a predator, that counter is moved to the predator triangle of the hex. (If there is no suitable prey in the hex, it must migrate or die this turn.)
- If a predator counter decides to become a plant-eater, it is moved from the predator triangle to on top of one of the biome cards or slots of the hex. Again, if there is no suitable biomes in the hex, the population counters must migrate or die this turn.
- Unless playing the "omnivore" option in the Advanced Game, the population counters of a particular genotype must be either all herbivore or all carnivore.

5.3.4 DISCARD TO MAXIMUM HAND SIZE The number of recessed cards a player may hold at this time cannot be larger than the number of genotypes (including the archetype genotype) in his size track. If he has too many, the excess cards must be either expressed (assuming no size incompatibilities), or else discarded.

5.4 POPULATION EXPANSION



5.4.1 POPULATION EXPANSION Each player increases its population by one for each genotype in every biome or predator triangle occupied by its genotype counters.

- Counters may be added to a hex in excess of its population limit. **Culling** of the extra population does not occur until the extinction period (5.7).

5.4.2 MAXIMUM POPULATION Each genotype is limited to the twelve population counters provided, or fourteen for the triangular **archetype** counters.

5.5 HERBIVORE MIGRATIONS



5.5.1 MIGRATIONS Each player moves some, all, or none of his herbivore tokens from the **biome** of one hex into another suitable biome of that hex or an adjacent hex.

- Animals with size three or more may move **TWO** hexes. Animals with wings may move **THREE** hexes (including over ice, water, bridges).

5.5.2 MOVEMENT ORDER The player with the most **r** dentition (see 2.4.1) moves first. In other words, the movement order is: **rrrr, mmrrr, rm, mmm**.

5.5.3 DESTINATION SUITABILITY Herbivores may end their move in a hex and move into its biome only if they are suited to it. The **biome suitability** requirements are shown by the letters in the upper right corner of the biome card, see the next paragraph. If there is nowhere suitable to go, they cannot move.

- **Amphibians.** Animals with more than one M DNA (marine) may exploit marine biomes (or their triangles) only. Animals with no M DNA cannot exploit biomes in totally marine hexes per 5.5.5. Animals with one M DNA (**amphibians**) are suited to any land or sea hex.

5.5.4 DNA CODE The **DNA** of animals and biomes is encoded with an upper case letter or letters, see 2.5.3 or map for code description. Herbivores must have these letters (A, B, G, H, I, M, or N DNA) to exploit a biome with A, B, G, H, I, M, or N DNA respectively.

- Biomes with an "X" DNA are inedible (sand dunes, ice-sheets, and some mountains).

EXAMPLE: A forest biome with tall conifers has a "BBB" requirement, so only those tall animals with three or more B DNA can eat these trees. "B" stands for "browse".

5.5.5 SEA BIOME HEX Marine biomes (crosshatched cards) may come and go periodically in lowland hexes.

- If a lowland hex has **TWO** marine biomes, (or one marine biome at biomass four), then this hex may only be entered or traversed by genotypes with wings or at least one M DNA.
- Empty slots count as marine biomes. (Advanced Game: Marine only if the greenhouse is 450 PPM or higher.)

5.5.6 ICE SHEET HEX (Advanced Game only) Cannot be traversed without PP DNA or wings.

5.5.7 POPULATION STACKING LIMITS None, but see second bullet of 5.5.1. Note that excess populations are reduced during extinction phase per 5.7.

5.6 CARNIVORE MIGRATIONS & FINAL SIZE



5.6.1 Beginning with the player with the most **m** dentition, each player moves some, all, or none of his predator counters from one hex's triangle into an adjacent hex triangle.

- Migration Range. Carnivores at size three or larger can migrate two hexes, and those with wings can fly three hexes.
- Suitability. The DNA codes for predator/prey is similar to that for herbivore/biomes. A carnivore must have an upper case A, N, or S to be able to prey upon animals with a, N, or S respectively, see 5.6.2.
- Armor. Note that the upper case A is for offense only, while the lower case a is for defense only. So, if a prey has aa, then a predator must have at least AA.

5.6.2 PREY SUITABILITY Predators may enter a **predator triangle** (2.2.4) of a hex only if there is suitable food (population counters) in that hex:

- Size: The predator must not be larger than the prey population counters, nor be more than two smaller.
- Armor (DNA A counters): The prey must not have more armor (a) than the predator has armor piercing (A).
- Speed (DNA S counters): The prey must not be faster (S) than the predator (S).

EXAMPLE: If a prey has SSS, its predator must have at least SSS, where each S stands for speed.

- Nocturnal (DNA N counters): The prey must not be more nocturnal or burrowing (N), than the predator (N).
- No Cannibalism: The predator cannot prey on members of its own genotype. It may prey on other genotypes, even of its own side.

NOTE (Advanced Game only): If the prey is larger, the predator is considered to be eating its eggs or young. Thus, any prey having child care cards cannot be preyed upon by any predator except those of the same size as the prey.

5.6.3 SEA & ICE Carnivores cannot traverse hexes with ice biomes nor with two marine biomes, except per 5.5.5 & 5.5.6.

5.6.4 CARNIVORE FINAL SIZE ADJUST After migrating, predators are allowed to change their size again, by one step. This is their final chance to become size suitable for their prey.

EXAMPLE: A carnivore may wish to migrate two hexes at size three, then shrink to size two to match the size two herbivore population there.

5.7 EXTINCTIONS



5.7.1 MAXIMUM SUPPORTABLE POPULATION

Each player removes (culls) surplus population according to the biomass of the biome or prey population, starting with the herbivores.

- For herbivores, the number of population counters cannot be greater than the biome biomass. For carnivores, the number of predator counters cannot be more than the prey counters.
- In the Basic Game, all biomes have a biomass of two, so they can each support two herbivore counters, which can in turn support two predator counters.

5.7.2 HERBIVORE NICHE COMPETITION

If more than one genotype is present in a biome, and there is surplus population to be removed, the "Niche" characteristic listed on the biome card (2.3.2) is used to decide who removes their surplus population.

EXAMPLE: In prairies it is the fastest animal that wins out ("Niche: S"), so that a genotype with two S DNA counters would survive over genotypes with only one or no S DNA. In reefs, it is the most marine ("Niche: M") that wins.

- If the Niche is "size", then the biggest genotype wins.

NOTE: Two genotypes peacefully share a biome card with no niche competition unless the hex capacity is exceeded.

5.7.3 HERBIVORE TIE-BREAKER If there is a tie in any herbivore niche competition, then the herbivore that cannot be eaten by any predators present wins.

- If a predator is present in a hex which can eat both competitors, then the predator player decides who lives and who dies. But if there is more than one competing predator that can eat both herbivore contestants, then see 5.7.4.

5.7.4 HERBIVORE FINAL TIE-BREAKER If there is still a tie in a herbivore niche competition, then the player with the most total dentition (longest dental formula) wins. Thus, an **mmrrr** herbivore wins over **mmm**.

NOTE: Players with two of their own genotypes competing for a biome or prey may decide which lives if both are suitable.

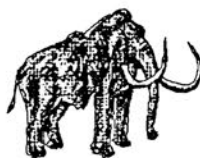
5.7.5 CARNIVORE NICHE COMPETITION First, remove any carnivores that no longer have suitable prey (5.6.2). If there is more than one predator counter competing for a prey counter, the biggest predator type wins. Thus, a size 6 carnivore would survive over a size 5.

5.7.6 CARNIVORE TIE-BREAKER In carnivore niche competitions, the player with the shortest dentition wins ties. Thus, an **rm** predator wins over **rrrr** or **mmrrr**.

5.7.7 EXTINCTIONS If the last counter of a genotype is lost, then its genotype card is discarded, along with all counters on it and all the DNA cards in its column.

- If a player's **archetype** goes extinct, he may designate a surviving genotype to be the new archetype (preserving heritage) for his clan (by exchanging counters). Its DNA cards are shifted to the left-hand column of its sheet.

6.0 Advanced Game



WARNING The Advanced Game is not much more complicated than the Basic Game, but it is longer to play and far more challenging for players to keep their genotypes alive. The addition of climate and geology changes America from a placid succession of biomes to a bucking bronco!

6.1 MILANKOVITCH CYCLES

6.1.1 DESCRIPTION The Earth goes through three great cycles in its orbit, referred to as the E, T, and P **Milankovitch cycles**. Each of these is kept track of by coins on the three map tracks in lower left corner.

- Each time that a player expresses a genotype card, one of these three cycles is changed according to the card.

EXAMPLE: If the genotype card says *Milankov T*, then the coin marking the T cycle is changed from the upper position to the lower, or from the lower to the upper.

- Milankovitch changes often have both land and sea effects. The instructions above the "waves" on the Milankovitch charts (map) describe the non-marine biomes, while that below the waves is for marine biomes.

6.1.2 BIOME FLUCTUATIONS In the Basic Game, all biomes were locked into a biomass of two. In the Advanced Game, the **biomass** of each biome can be adjusted by rotating the cards, and the total biomass of the hex is limited to four. In other words, the biomes in both slots of a hex cannot exceed four in their combined biomass. Hexes are still limited to two biomes.

- This biome card has a biomass of three in its sideways orientation, since the number three is upright. The biome (if any) that shares this hex can have no more than a biomass of one.
- Biomes reduced to zero go extinct.



6.1.3 BIOME PREFERENCES Some biome cards have preferences, as listed in the upper left corner of the biome card (see 2.3.2). These preferences can be "wet", "dry", "seasonal", "warm current" and "cold current".

- These preferences can raise or lower the biomass during biome migration or displacement, as well as during Milankovitch changes.

6.1.4 SEASONAL BIOMES If the T Milankovitch cycle turns the hemisphere more seasonal (increasing the temperature difference between summer and winter), then any biome cards that have the "seasonal" preference (listed in the upper left corner) increase their biomass by one. This is shown by rotating its card by 90° counter-clockwise.

6.1.5 DRY AND WET BIOMES If the E or P Milankovitch cycle turns the hemisphere drier, then the dry-loving biomes are increased one in biomass, while the biomes with wet preferences are simultaneously reduced one in biomass.

6.1.6 WARM CURRENT AND COLD CURRENT BIOMES If the E Milankovitch cycle changes the current to warm, then all warm current marine biomes are increased one, and cold current biomes are decreased one.

6.1.7 CULLING If after adjusting for preference, the hex capacity is exceeded, the excess biome mass (**biomass**) is reduced (**culled**) per the **climax**, see 6.4.3.

6.1.8 EROSION In the Milankovitch T cycle, there can be an erosion episode in which extended rainfall wears down the **Orogeny** (mountain) biomes. Each time the T cycle changes to an erosion result, reduce each orogeny biome by one biomass.

6.1.9 MARINE HYPOXIA Also in the Milankovitch T cycle, the biomass of every marine biome is reduced by one due to a drastic oxygen depletion in the oceans.

6.1.10 MARINE BLOOMS As called for in the T cycle, every marine biome is increased one due to increased upwelling of nutrients from the ocean's depths. If the hex capacity is exceeded by this action, the lower climax biome is reduced.



6.2 CATASTROPHES

6.2.1 COMMENTARY If a catastrophe card is revealed, then first each player receives five gene coins. This is doubled if a player has any expressed **sex cards** (5.2.7).

- Each catastrophe card has a "Mesozoic" and a "Cenozoic" edge, see 2.3.5. Use the Mesozoic side if it was one of the first 37 cards drawn on the timeline, and the Cenozoic side if it was one of the last 14 cards.

6.2.2 EXTRATERRESTRIALS In this game, extraterrestrials refer not to alien life but to catastrophic events from beyond the Earth, like bolide impacts and exploding stars (**supernovae**). They tend to **cull** over-specialized genotypes, while leaving **generalized** animals unscathed.

- If a card states "Extinction: > 3 AaMS", then all genotypes and immigrants with greater than three DNA combined of the A, a, M and/or S allele go extinct. Both **heritage DNA** and DNA counters count. Example: a bird genotype with APSS would not go extinct, but another bird with AAMS would die.
- If a card states "Extinction: triple S", then any genotype with three or more S DNA removes all its population counters.
- If a card states "Extinction: size > 4", then any genotypes (or immigrants) currently at size 5 or 6 go extinct.
- Note that population size is no protection against extraterrestrial extinctions (or any other kind).

6.2.3 GREENHOUSE A coin in the map's Greenhouse Level track is used to monitor the Earth's **greenhouse effect**. Due to greenhouse gases (and to a lesser extent, continental drift) climate changes may force plants to advance or retreat in latitude per 6.3.1. In cooler times, for instance, cactus lived close to the equator; as the earth warmed up the cactus migrated to the **horse latitudes** they are found in today.

- If the greenhouse level reaches to 600 ppm (parts per million of **carbon dioxide** in the atmosphere), plant growth is enhanced. All biomes (except **orogeny**) increase their **biomass** until the hex capacity of four is reached. If there are two biomes in a hex, the higher **climax** non-orogeny biome expands to fill the empty space (but does not displace or reduce the lesser climax biome).
- If the greenhouse level reaches 600 ppm, then after biome migration the **sea level** rises to flood all **bridges**, put a coin in all three. However, if it drops to 200 ppm, the **Beringia** bridge has its coin removed (if a coin was present). If it drops further, to 150 ppm, then the Panama bridge is open as well, if it had a coin indicating flooding.
- If the greenhouse goes over 600 ppm, or below 150 ppm, then the game ends, see 6.8.2.
- The greenhouse level is used in genotype cards auctions (5.1.3).

6.2.4 PANDEMICS All organisms have DNA to summon the anti-bodies, etc. needed to fight disease and parasites. If a **pandemic** card arrives, the player (or players, if tied) with the fewest gene coins available and having more than one genotype chooses one of his **genotypes** to go extinct.

- Players with only one genotype are immune to pandemics. 

6.2.5 BRIDGES There are three land bridges on the map; and a coin upon them indicates that the bridge is flooded. If a catastrophe card changes a bridge's state, then a coin is added (if bridge flooded), or taken away (if open).

- Catastrophe Cards can open or flood bridges regardless of the greenhouse level. 
- If a flooded bridge becomes open, then any immigrants in the holding area migrate per 6.5.2.

6.3 BIOME MIGRATIONS

6.3.1 GREENHOUSE If the **greenhouse effect** increases due to a catastrophe card, then all biomes (except orogeny biomes) are shifted northward by one hex to reflect the warming conditions. If the greenhouse goes down, all biomes are shifted down one hex. All genotypes remain in place until the migration period.

6.3.2 MIGRATION ARROWS Biomes shifted by greenhouse follow the arrows marked on the map, according to the biome type. Marine biomes follow the arrows marked with the crab icon, and ice-sheet icons follow the arrows marked with a snowflake. All other biomes follow the terrestrial migration arrow, as marked with a tree.

- Biomes migrating north from the Sierra Madre have a choice of two arrows, they take the right one if in the East Sierra Madre, and the left if in the West. Biomes migrating north from the **Zechstein** Sea go right (to Spain), unless the bridge is flooded, in which case they go left to Greenland. Marine cards entering the Atlantic are stacked with the easternmost slot on the bottom, and the westernmost on top. If migrating north from the Atlantic, the top two cards enter the Gulf of Mexico, west to east, and any further cards enter the Zechstein Sea, west to east. In other holding zones with biomes, the top two cards (only) migrate out.

6.3.3 MOUNTAIN MIGRATIONS These never migrate, except for the African plate (which can migrate south

into the Atlantic Ocean only) and the Spanish plate (which can migrate north into the Island of Spain only).

- These "migrations" represent continental drift (**plate tectonics**), and only occur if Spain or Africa is displaced (bumped by a higher climax biome), or if the Greenhouse goes up (for Spain) or down (for Africa).
- 6.3.4 ICE-SHEET MIGRATION** These migrate just as other biomes do, but follow special migration arrows marked with a snowflake (*).
- The ice-sheet biomass of four fills the entire hex, so that the other slot in the hex is forced into extinction if it is a lower climax. If a biome and an ice-sheet (or two ice-sheets from a holding zone) enter the same hex, the advance of the lower climax biome is retarded (kept inside the holding zone or hex).

6.3.5 HOLDING ZONES Biomes forced to migrate off the map hexes (for instance, a Panamanian rainforest forced to migrate south) are moved into a holding zone as indicated by the map migration arrows. See 6.4.4.

- Biomes in the northernmost holding zones of Asia, Angaraland, Europe, or Spain remain in place if forced to migrate further north. Similarly, biomes in South America or the Atlantic forced to move south remain in place instead. Biomes also remain in place if blocked from migration by ice, or a flooded bridge (6.2.5). Biomes enter (and remain in) holding zones without changing biomass.

6.3.6 EXPLOITATION OF BIOMES IN HOLDING ZONES (optional) This optional rule allows genotypes to enter the top biome card (or its triangle) in a holding zone as if it was an additional game hex. The first herbivore entering the zone decides which card to put on top. All rules for hexes (**niche competition**, etc.) apply.

- Each holding zone counts as a movement point for migration purposes. Animals with wings may fly over flooded bridges.
- Animals must have two or more "M" DNA to enter the Atlantic Ocean holding zone.
- Holding zones have no latitude or moisture preference.
- If playing this rule, immigrants may either exploit the most suitable biome within its starting holding zone, or wait for the bridge to open to invade mainland biomes per 6.5.2.

6.4 POST-MIGRATION CLIMAX

6.4.1 MOISTURE PREFERENCE A migrating biome card with a wet or dry preference adjusts its **biomass** by one according to the latitude that is moved into, see 6.1.5. Some latitudes, like the **horse latitudes**, are dry, while others, like the tropical latitudes, are wet, see map.

EXAMPLE: Ferns with a "wet" preference and at biomass one grow to two upon entering a wet tropical latitude, but reduce from one to zero, going extinct, if migrating into a dry latitude like the Arctic.

- This adjustment will instantly shrink the biomass of the other biome in the hex if the hex capacity of 4 is exceeded, regardless of climax. (An exception to 6.4.3.)

6.4.2 HEX STACKING Only two biome cards may occupy a hex (one per slot). If, due to greenhouse shift, a hex has more than two biomes, the extra biomes go extinct per the **climax** procedure in the next paragraph.

6.4.3 CLIMAX CULLING If a hex has two biome cards whose biomass adds to more than four, or has more than two biomes, then the cards with the lowest climax reduce biomass or are removed until the hex is in equilibrium.

6.4.4 CLIMAX IN HOLDING ZONES The card capacity of a holding zone is listed on the map. If there are too many cards, the lowest climax ones go extinct (discarded).

6.5 IMMIGRANTS



6.5.1 COMMENTARY Animals and plants native to America have adapted defenses against the American animals that prey upon them. This balance of nature can be destroyed when foreign **immigrants** gain access. Rather often, the natives are naive or defenseless against new threats that have evolved elsewhere. See 2.3.6.

- In this game, the impact of invaders is limited to one biome or predator triangle (unless optional rule 3.6.2 is used). The presence of immigrants is shown by either having their card in that biome, or by using spare population counters.

6.5.2 IMMIGRANT PLACEMENT Immigrants enter by crossing a land bridge or by swimming into the Gulf of Mexico from the ocean. They seek the first suitable home (that they can out-compete the local creatures, if any) using unlimited migration movement. Each immigrant has one "wild" (W) DNA that will transform into the most suitable DNA (except H) for exploitation of that spot per 5.2.6. If the "W" is not needed, it is dropped and can't be used later.

- Immigrants check slots from west to east, until a suitable one is found. Immigrants from the Asia check the northern latitudes first, and move south, while immigrants from the Atlantic or from South America check southern slots first. The card is discarded if no suitable slots are found.
- Atlantic immigrants are restricted to marine biomes, while Asian or South American ones are restricted per 5.5.5.
- If the bridge from the holding zone is flooded, then the immigrant card is placed into the holding zone and will not invade until the bridge is clear per 6.2.5.
- When deciding if herbivore immigrants are suitable for a biome, ignore the effect of any predators present.
- Immigrants will not try to compete with other immigrants.
- Immigrants without M DNA can't enter areas (like Greenland) if blocked by hexes with two marine biomes apiece.
- Immigrant cards or counters remain there (but following biome migrations 6.3) until they lose **niche competition**.

6.5.3 IMMIGRANT DENTITION All immigrant **dentition** is either formula length one ("r" or "m") or formula length six (like "rrrrrr"). The former are the carnivore immigrants, they will enter the first suitable predator triangle. The "six tooth" immigrants are the herbivores, and they will enter the first available suitable biome.

6.5.4 IMMIGRANT BIOMASS Upon entry and during each population expansion period, immigrant cards automatically alter their **biomass** to match the biome or prey. This is done by rotating the card in a similar manner to the biome biomass per 6.1.2.

6.5.5 GENETIC DRIFT Each land immigrant card revealed causes **genetic drift** to occur. Every player is forced to discard one recessed card from their hand.

- Players without cards in their hand ignore genetic drift.

6.6 HUSKERS



6.6.1 COMMENTARY Seeds are small packages stuffed with enough nutrients to germinate and grow a new plant until it can initiate its own solar-powered processes. The high energy contents of seeds are usually well protected by an indigestible husk. Certain small animals, called **huskers**, have developed ways to crack this shell and digest the nutrients.

NOTE: Today, the dominant huskers are songbirds and rodents.

6.6.2 HUSKER DNA Huskers carry the H DNA, which permits exploitation of biomes with **mast**. The **biome requirements** are H (other biome requirements are ignored), and the niche is as printed on the biome card.

6.6.3 MAST Certain biomes, as marked on their cards, contain "**mast**", a term for seeds edible only by huskers. Mast doubles the number of genotype counters a given biome biomass can support (in effect, makes it into two biomes). For instance, an oak biome at biomass three can support three herbivores plus three huskers, as suggested on the oak card. And yet mast biomass does not count towards the general hex capacity of four.

- Counters that decide to husk should be moved to just below the biome card, within the lower triangle, during trophic change.

6.7 OMNIVORES (Optional Rule)

6.7.1 OMNIVORES Both mammal players have the option (during trophic period) to position some counters of a genotype as carnivores, while others of the same genotype are herbivores.

- The ruling reptile players do not have this option, as each kind of their genotypes must reside either in a **predator triangle** or on a biome (not split between).
- **Omnivores** are prohibited from preying on their own kind of genotype, however. (Cannibalism is disallowed, however, there is nothing prohibited about a player having one of his genotypes eating another of his genotypes.)

6.8 VICTORY CONDITIONS

6.8.1 COMMENTARY The winner is the player with the most population counters (counting all of his genotypes) on the map at the end of the game.

6.8.2 END OF THE GAME This occurs when one of the following happens:

- The last card is played (the Pleistocene/Holocene).
- Only one player has population counters left.
- All players agree to halt.
- A predetermined time limit is reached.
- The Greenhouse goes over 600 ppm or under 150 ppm.
- (Optional): Hominids ("cavemen") invade America.

6.9 EXAMPLE OF PLAY

TWO PLAYER ADVANCED GAME

This is an actual game, 3 hours long, on 97-07-10.



- Reptile player is **rm** dentition rabbit-croc.
 - Mammal player is the **mmm** dentition dog-face.
- The rabbit-croc puts a population counter in the ginkgoes of Laurentian Shield, so does the dog-face.

CARD ONE [54] First card is ability to drink seawater, DNA MM. (The number in brackets designates the card number.) Neither player wants this card at this point, it is too restrictive. Both players grow to size two, multiply their population to two apiece, and scatter from the Laurentian ginkgoes to adjacent sites (Greenland, Spain, Appalachia).

CARD TWO [111] Turtle genotype. Each player bids one gene, then escalates to three apiece. The reptile wins this tie. He expresses it immediately, which accomplishes Milankovitch P. Dry biomes, like lichen in Alaska, go down to biomass one, and wet things, like the rainforest, go up. Note that the ginkgoes next to the rainforest in Laurentia are forced down to biomass one, even though they have no wet/dry preference and even with a higher climax. The dog-face now has four counters, the reptile also has four, half rabbit-croc and half tortoises. All populations are herbivorous and size three.

CARD THREE [66] Tool Use W DNA. Neither player is very interested in this card, as it cannot be expressed without first acquiring other cards, which may never come up. It seems likely that, if bought, this card will fall to genetic drift, yet the reptile decides it may be worth one gene and the mammal lets him have it. A fatal mistake! During trophic, the rabbit-croc switches to carnivore. The turtles, with IMaa DNA, start to crowd out the dog-faces in three sites that have a "Niche I", which are the cloud forest, the rain forest, and Spain.

CARD FOUR [73] Antlers "sex" DNA! Obviously both players lust after this card, so the mammal puts three genes on it instantly. Since the reptile has but three genes left, and ties on antlers go to the mammal, the dog-face is quickly adorned with a proud rack. It seems that the game is lost for the reptile. However, his turtles, having taken over all the wet forests, now spread into ginkgoes (Niche P) plus ferns in Greenland. The turtles win because they are double-armored and inedible to the local rabbit-croc predators, who can eat dog-faces. In desperation, dog-face grows to size five and moves into the two biomes with "Niche: size". The turtle's size limit is four, so dog-faces can survive in these two: seed ferns [168] in Appalachia, and lycopod meadows [171] in the Sierra Madre.

CARD FIVE [99] Thumb Spike BIa DNA. Disaster for the mammal, as he has no genes and the reptile picks this up for a gene. Not only does the thumb spike have great DNA, but it also happens to be the card allowing him to express the tool use (W) card in his hand. The predators now have thumbs and tools, and the reptile launches his plan to drive the dog-faces extinct and out of the game before he can use his sex. Population at this point: Dog-face: 3 (the meadows are down to biomass one due to Milankovitch, so one there and two in seed ferns); Rabbit-crocs: 3 (eating dog-faces), and the turtles have pegged their population counter count at 13.

CARD SIX [144] Choristoderans invade, strange crocodile-like South American immigrants. They have DNA of MW, and a size range of 1-4, and first try to eat the size five dog-faces in the meadows of the Sierra Madre. Since they are bigger

than the native rabbit-croc predators (limited to size three by tool use), they win, and bump both **rm** counters.

CARD SEVEN [103] Retractable Claw N DNA. The mammals buy this, and the dog-faces go nocturnal, hoping to drive the predator extinct. But the rabbit-crocs cheerfully announce that they have invented the torch, designating their tool use W DNA to N.

CARD EIGHT [47] Beringia Bridge closes, a very mild "catastrophe". The mammal gets ten genes, the reptile but five. The mammal is very close to extinction, only three population counters on the two "Niche: size" biomes. But they are at size five and have more teeth. The reptile decides to go for broke, growing to size four (forcing a recess of tool-use, risking genetic drift), and switches to vegetarianism. He displaces turtles so his newly herbivorous dinosaurs have a home. His plan is to grow big enough to knock the mammal herbivores out of their size-niche biomes and out the game. The Triassic is now over; the Jurassic begins.

CARD NINE [114] The mammal desperately buys the dolphin genotype, eating primitive fish in the Epeiric seaway (which induces the reptile to abandon his risky extirpation effort).

By the end of the Jurassic, the mammal gets deer and camels, which turn out to be poor investments. On turn 32 (mid-Cretaceous), the dinosaurs get technology (!), and invent fishing poles (fishing for both dolphins and rays in the Gulf). The techno-predators, now with bows and arrows, kill off the dolphins and camels. The dog-faces barely hang on as huge generalized predators feeding on generalized prey, and the deer are forced into Europe and survive only by being triple speed and nocturnal. The turtles remain inedible, even to the now humanoid dinosaurs. Toothed birds and Pachycephalosaurs come but don't live long.

FINAL POPULATIONS (Quaternary Period):

REPTILE: turtles: 13, techno-dinosaurs: 9, brontosaurus: 9
MAMMAL: dog-face: 4, swift nightdeer: 4, giant tillodont rats: 4
Victory: Ruling reptiles!

6.10 DARWINIAN VARIANT

6.10.1 COMMENTARY The standard games put the predators into the role of "game wardens", giving them the choice of which herbivores live and die in many instances. (*"In any non-self-running simulation, there must be Lamarckian appeals."* Mike Wasson) Players may enjoy the following variant, which takes away this king-making ability from the carnivores.

6.10.2 HERBIVORE TIE-BREAKER In this variant, replace the bullet in 5.7.3 with "• If the predator or predators can eat both competitors, then see 5.7.4".

6.10.3 STARTING DNA To avoid the savage "sudden death" effects of the Darwinian starting game without a "game warden", give the **mmm** archetype a "P" DNA heritage (representing its fur), and the **rrrr** archetype an "A" DNA heritage (representing its big, slashing, attack jaws), if there are three or more players.

- These are heritage (non-inheritable) DNA.

7.0 Background



7.1 THE ANIMALS

7.1.1 THE GAME OF BIG GAME This is a game about game, big game. How big? Well, we are not talking lions and tigers and bears big. A Manchurian Tiger weighs in at 325 kg, that's only size two in this game. Hippos, at 1300 kg, are only size three. No, we are talking really big. Brachiosaurs, featured in the movie Jurassic Park, and which have been recently found to have survived into the mid-Cretaceous here in Arizona, massed up 70 tons or more!

7.1.2 MEGAFAUNA ADVANTAGES Large animals are often faster, migrate further, and can catch bigger prey than small ones. Big animals do not need high metabolisms, so that weight per weight they need less food than small animals. Finally, large animals have smaller populations than large ones, given a constant resource. Smaller populations have more speciation. On the other hand, smaller populations have more **genetic drift**.

7.1.3 BIG WARM-BLOODS One significant advantage of being big, if one is warm-blooded, is a favorable surface area to volume ratio. One can visualize this principle by observing how fast a given amount of ice melts in cubes compared to if it is in one big block. Tiny warm-bloods like shrews must eat continuously to maintain their heat. Such **homiotherms** need lots of high energy food (insects, seeds, etc.).

7.1.4 NO AMERICAN MEGAFAUNA? In all the world, America has had the most and the biggest dinosaurs by far. Yet although the conifer forests are still here, Brachiosaurs no longer roam in them. This continent is impoverished in big game, compared both to its past and to modern Africa.

7.1.5 LEAVES By far the most abundant terrestrial food is low-energy leaves, watery and full of fiber. Only 30 to 70% of the contained energy of leaves is usable, compared to 70 to 90% for high energy foods (fruit, rodents, insects, fish, seeds). The smallest leaf-eating warm-bloods are the rabbits and sage grouse (these uncommon American birds have a diet that is 71% leaves & flowers of the sagebrush). Smaller homiotherms will eat some leaves, but would starve if forced to subsist on them.

7.1.6 GUTS Most of the energy of a leaf is locked up in cellulose, the most common component of fiber. No known animal can digest fiber by itself; leaf-eating animals must employ long digestive tracts filled with special bacteria in order to extract energy from cellulose. Two basic ways in which large herbivorous dinosaurs and mammals digest leaves is foregut digestion and hindgut digestion. In today's biomes, midsize herbivores tend to be foregut digesters like **ruminants**, while the larger herbivores (elephants, rhinos, hippos, horses) are hindgut digesters.

7.1.7 GRASS The warm, wet forests were largely replaced by the cool, dry grasslands during the Miocene. This cooling was the result of the rise of the Tibetan plateau which leached greenhouse gases from the atmosphere on a planetary scale. Grass is particularly hard to digest, see **graze**. Cattle, deer, and other **ruminants** are today's most advanced grazers; such cud-chewers are currently driving the larger hindgut digesters out. Rhinos, elephants, and horses will be extinct in a million years or so unless man gives them sanctuary.

7.1.8 APOLOGIA It is debatable allowing size two animals (80-400 kg) to fly. The heaviest known flyers are two American animals: the pterodactyl *Quetzalcoatlus* (65 kg?), and the teratornes (extinct vultures of 10,000 years ago, 120 kg?). Bustards, today's heaviest flyers, mass 23 kg.

An apology on nocturnal animals. Most mammals today are active at night, leaving the birds to dominate the day. I have made my rabbits, dogs, etc. active in broad daylight, as I envision the masters of the Earth should behave, rather than skulking about at night.

7.2 THE SCOREBOARD

7.2.1 MAMMAL ADVANTAGES Who will win, archosaurs (dinosaurs/birds) or mammals? In this game, the mammal genotypes seem more robust than the dinosaur ones, and enjoy the "omnivore rule (6.7)" versatility, perhaps reflecting my "mammalian chauvinism". And the mammal's heterodont **dentition** gives them not only the tie-breaking edge in procuring most tooth DNA cards, but also an ultimate advantage in herbivory as well. They also have a "turn order" jump on the reptiles (who are forced to move first). Finally, the mammals have a significant IQ advantage, see **intelligence** for more on this. This gives them more P DNA, an advantage in high climax deciduous forests.

7.2.2 ARCHOSAUR ADVANTAGES The ruling reptile genotypes tend to be bigger, faster, and to experiment more with armor. (Only 4% of today's mammals, mainly the *xenarthra*, exhibit any armor, while 19% of fossilized dinosaurs species exhibited armor.) Archosaurs have dominance in acquiring genotypes at most **greenhouse** levels, and the rabbit-crocs have a **dentition** advantage in meat-eating.

7.2.3 SCOREBOARD This table analyzes which dynasty has the edge in *American Megafauna*, and which is winning in today's populations:

RULING REPTILES vs. MAMMALS SCOREBOARD

North American ECOMORPH	No. of Biomes in the Game	GENOTYPES R = Ruling Reptiles M = Mammal	DNA Card Advantage	Who won as of today?
TOP PREDATOR (ASS or AAS)	~10	R: Carnosaurs, pliosaurs M: Cats, dogs/bears, toothed whales	R: 6 M: 6	MAMMALS <i>Carnivora</i> (Cats, dogs/bears)
NOCTURNAL PREDATOR (N)	~4 +5 niche	R: Coelurosaurs, pliosaurs M: Cats, cetaceans (whales)	R: 2 M: 3	RULING REPTILES (Owls)
INSECTIVORE (I)	5 +5 niche	R: Turtles, pterosaurs, toothed birds, songbirds M: Anteaters, pangolins, shrews, bats, panthothes	R: 2 M: 3	RULING REPTILES (Songbirds) also insects & spiders
SHALLOW WATER (M)	10 +5 niche	R: Nothosaurs, pliosaurs, pterosaurs, crocodiles, toothed "penguins", shorebirds M: Pinnipeds (seals), sirens	R: 4 M: 0	RUL. REPTILES (Crocodiles, ducks, cranes) also fish, snakes & turtles
OPEN OCEAN (MM)	3 +5 niche	R: (none) M: Cetaceans (whales)	R: 1 M: 1	MAMMALS <i>Cetaceans</i> (whales), & fish
BROWSER (B)	14	R: Prosauropods, sauropods, hypsilophodonts, stegosaurs, horned dinosaurs M: Marsupials, camels, elephants, chalicotheres, rhinos, ruminants	R: 5 M: 4	MAMMALS? (Some ruminants like deer, but oddly this niche is largely empty)
GRAZER (G)	14	R: Ankylosaur, boneheads, ostrich dinosaurs, duckbills M: Rabbits, horses, camels, swine, rhinos, elephants, ruminants	R: 4 M: 4	MAMMALS (Rabbits, ruminants like bison, pronghorn, deer) also insects
HUSKER (H)	18	R: Songbirds, doves M: Rodents, tillodonts, hyraxes	R: 1 M: 1	RUL. REPTILES (Songbirds, doves) also ants
INTELLIGENCE (PP)	none +11 niche	R: (none) M: Primates, Cetaceans (whales)	R: 8 M: 9	MAMMALS (Humans)

- 7.2.4 TOP PREDATOR** Game Advantage: Dinosaurs! The dinosaurs have two big advantages, first big advantage is that they are big, and size rules in predation. And, secondly, the reptile tooth pattern also favors predation, see dentition. Today's Winners: The mammalian order *Carnivora*, (grizzly bears, wolves, cougars) which exhibit a great deal of dietary versatility (see omnivore).
- 7.2.5 NOCTURNAL PREDATOR** Game Advantage: Dead heat! Big-eyed dinosaurs and sea monsters evenly match the great cats and sonar whales. Bats, shrews, and mice are deemed too tiny to be worthy predators. The four niches listed include the likely appearance of nocturnal rodents to eat, and two Arctic biomes with niche N (for the six months of darkness). Today's Winners: Upset! For 200 million years, mammals have ruled the night like little furry vampires! Even today, most mammals, with their keen sense of smell, are nocturnal. But recently, a dinosaur clan predator, with "offset" hearing and huge eyes, has overtaken the mammals in the "midnight rodent crunch" contest. I refer to owls, which even occasionally eat the very cat and bat animals that would have been the leading mammal nocturnal contenders.
- 7.2.6 INSECTIVORE** Game Advantage: Mammals. The furballs have slightly more insect-eating DNA and genotypes. Today's Winners: Upset! Songbirds.
- 7.2.7 SHALLOW WATER** Game Advantage: Dinosaurs! It is not even close. But America today has none of the shallow warm sea habitats of the Mesozoic. Today's Winners: In fresh water biomes, cold-bloods have about 1300 species of frogs, turtles, and salamanders, compared to only 50 species of water shrews, otters, and beavers. (The only surviving warm-blooded megafauna that lives in shallow water is the hippopotamus of Africa.)
- 7.2.8 OPEN OCEAN** Game Advantage (and today's winners): Mammals, with their baleen and toothed whales (a fifty tonne sperm whale is the largest carnivore ever). It is a mystery why dinosaurs themselves never returned to the sea like the mammal carnivores have (and penguins).
- 7.2.9 BROWSERS** Game Advantage: Dead heat! Animals that browse stretch upwards to obtain the leaves of trees, which tend to be more succulent than the low plants. Mammals have more browsing genotypes, but the dinosaurs tend to be taller and perhaps eat more trees than the mammals. Today's winners: Nobody! To my eyes, the pine needles and leaves of Americas forests are largely untouched (except by caterpillars) and the place is ripe for the return of elephants, or brontosaurus. Huge pachyderms, prematurely extirpated by blitzkrieg, could return someday.
- 7.2.10 GRAZERS** Game Advantage: Mammals (maybe). This biome type includes the very high climax grass prairies, and its dominance is vital to win the game. Grass did not appear until the Oligocene, so not only did no dinosaurs eat grass, no ruling reptile that I know of has ever attempted this tough regime. (One American reptile, not a ruling reptile but an anapsid, that grazes is the amazing Desert Tortoise.) Today's winners: The grasslands are where "the deer and the antelope play". Other successful ruminants are bison and cattle. But don't underestimate the archosaurs (dinosaurs & birds), some of which (duckbills, horned dinosaurs) have some of the most formidable chewing teeth known. Additionally, speed is vital on the prairies. Archosaurs, with

their mastery of wings and bipedal sprinting, tend to be far faster than mammals in this game.

- 7.2.11 HUSKERS** Game Advantage: Dead heat! Mammals have one more genotype, but the birds have all the spectacular husker genotypes. Today's winners: Songbirds (especially sparrows and finches) and the doves.

7.3 THE TRIASSIC CONTEST

- 7.3.1 PERMIAN** Perhaps the greatest mass extinction ever took place at the end of the Permian, destroying most of the proto-mammal Tartarian groups. During the resulting Synthian radiation, other mammal-like therapsids developed to replace the fallen: the two-tusked dicynodonts as plant eaters, and the cynodonts (with dog-like faces) as meat eaters. The first archosaur (ruling reptiles) forms would be the "crimson crocs" (erythrosuchian thecodonts), so named for the red stains of the first bones unearthed. Other small active thecodont archosaurs, such as the semi-bipedal lagosuchids, were dubbed "rabbit crocs".
- 7.3.2 TRIASSIC** The Triassic was a mighty clash of two nascent megadynasties. The first, archosaurs, would rule the Mesozoic, and the second, mammals, would rule the Cenozoic. But in the Triassic, at the dawn of the Mesozoic, both dynasties began on equal footing. (Both were surely warm-blooded, for instance). This is where our game begins.
- 7.3.3 JURASSIC** Coastlines are similar to today's. The archosaurs are supreme, first dominating the top predator slots, and then supplanting the herbivores. They quickly radiate into fantastic forms: dinosaurs, pterosaurs, crocodiles, birds. The plant-eating two-tuskers and rhynchosaurs were extinct by the end of the Triassic, and the dog-faced cynodonts would not survive the Jurassic. However, one cynodont group evolved into the first true mammal, a small egg-laying shrew-like animal.
- 7.3.4 CRETACEOUS** A seaway full of giant marine reptiles divides America into East and West halves, and the world is warmer and cloudier than any age since. The dinosaurs evolve to spectacular heights, then die off under suspicious circumstances. The tiny mammals, reptiles, & birds survive.
- 7.3.5 TERTIARY** Mammals rule and dinosaurs drool! Was it inevitable? I have tried hard to avoid determinism in this game (although there is some in the tie-breaking and climax rules). A comet, or even two, may smite the Earth, or maybe not. The dinosaurs, or the mammals, may or may not survive. The tree of life, as Steven Jay Gould puts it, is more like a bush. A bush with a stalk (the archetype) radiating out into thousands of twigs. A bush that is repeatedly pruned such that only a few twigs survive, some of which start new bushes. The continental "froth" that is America floats in a basalt "sea" of plate tectonics, and is buffeted hither and yon at random in its leisurely meander, oblivious to its hapless biological components. Yet those creatures are not nearly as fragile or hapless as they look, as they employ subtle Gala controls. Each time one plays *American Megafauna* the tape of life is rewound and replayed. And the answers won't ever be the same.
- 7.3.6 QUATERNARY** And this contest is not yet over. The archosaurs live on as birds, whose scaly bipedal feet belie their dinosaurian past, and wait their opportunity to regain world domination. If numbers of species is counted, they have already won it.

Phil Ekfund, May, 1997

7.4 GLOSSARY & INDEX

Allele Any of the different forms of a gene that occupies a particular locus.

Ammonites These are related to squid and octopus, but live in coiled and chambered shells and swim in great schools. They rise near the surface to feed at night, hence their nocturnal rating. They were nearly wiped out during the Permian and then the Triassic mass extinctions, only to rebound greater than ever during the time of the dinosaurs, along with the belemnites (armored squid). But the ammonites did not survive the Cretaceous mass extinction.

Amphibian Genotypes with no M DNA cannot go into all sea hexes or the Atlantic, and genotypes with two M DNA cannot leave marine biomes. But animals with exactly one M DNA can go anywhere, they are called amphibians.

Angaraland The ancient continent comprising present-day Siberia and Kazakhstan. At the game's start, it has just collided with the continent of Laurentia (combined North America & Europe), forming the Siberian traps. This combined plate, called Laurasia, has moved to the North and West for the last 300 million years, slowly rotating anti-clockwise. Europe/Angaraland have separated occasionally from Greenland/America, as they are today.

Angiosperms Plants that form seeds that develop from flowers, including deciduous broadleaf trees, flowering shrubs, grasses, palms. These are the most complex of the plants and their appearance in western Gondwanaland during the Cretaceous rapidly spread to global dominance. Angiosperms have a distinctive love-hate relationship with animals: depending upon birds and mammals for seed dispersal, and upon pollinators (mainly insects) for fertilization. Symbiotic flowers and fruits were developed to attract animals, while protecting the edible leaves with various insecticides, spines, etc.

Archetype [2.3.3, 2.4.1] The original forerunner of a group of animals or plants. In this game, there are two ruling reptile archetypes and two mammal archetypes, represented by the red cards the players start with. All four archetypes in this game are high-metabolism (see homiothermy) quadrupeds (or bimodal quadruped/biped), with unspecialized five clawed toes, suitable for catching prey, digging, running. Locomotion is plantigrade (walking on soles), with an up and down backbone flexure, contrasting with the side to side flexure and sprawling posture of the ancestral cold-blooded reptiles like lizards or sail-backed pelycosaurs. Furthermore, the archetype digestive system is short, suitable for meat, insects, seeds, or sugar, not low energy leaves. The archetypes in this game differ mainly in their teeth, see dentition. The **rm** dentition archetype corresponds (roughly) to the ancestor of the pterodactyls and saurischians ("lizard hipped" dinosaurs), including the camosaurus, brontosaurus, and birds. The **ffff** archetype is ancestral to the toothier ornithischians ("bird-hipped" dinosaurs), including the plant-eating horned, duckbill, armored, and bone-head dinosaurs. The **mmm** corresponds (perhaps) to the mammal carnivores (dogs, cats, bears, pandas, seals, and perhaps creodonts, primates, bats, and shrews). And the **mmfff** (irreverently called "wiener dogs") is perhaps ancestral to the glires (rodents, rabbits), artiodactyls (even-toed ungulates), perissodactyls (odd-toed ungulates), and proboscids (elephants).

Archosaurs "Ruling Reptiles", a subclass which includes thecodonts, crocodiles, pterosaurs, dinosaurs, and birds.

Arthropods A phylum comprised of all creeping and flying invertebrates, such as insects & crustaceans, which dominate the terrestrial animal biomass.

Beringia A land bridge between Alaska and Siberia, that formed and flooded during the late Cretaceous (to Eurasia), Eocene, and Pleistocene. It was by this bridge that Asian dinosaurs and mammals of many kinds, including humans, have emigrated to America. And American immigrants have gotten to Asia, as well. Beringia remained ice-free during the ice ages. Today, Beringia (Alaska) has America's largest megafauna, like polar bears, whales, and walrus. (But no large cold-bloods, like alligators.) Small animals have excessive heat loss due to an unfavorable surface area to volume ratio, see 7.1.2.

Biomass [6.1.2] The weight of living matter. Each biome point (there are up to four points per hex) represents 2000 megatons of vegetation or invertebrates. Each genotype counter represents either 30 megatons of herbivores, or 1 megaton of predatory animals. A "megaton" is a million tonnes, where each tonne is 1000 kg (also called a metric ton).

Biome Preferences [6.1.3]. The climate tolerance of a biome, which raises or lowers its biomass during migrations or Milankovitch changes.

Biome Requirements [5.5.3]. The minimum DNA required for an animal to be able to enter a slot.

Biome [2.3.2] A major ecological community characterized by distinctive vegetation, invertebrates, or fish that can be exploited by animals that meet certain DNA requirements.

Blitzkrieg This theory proposes that recent (Holocene) mass extinctions of American megafauna such as giant armadillos, camels, horses, mammoths, cave bears, giant ground sloths, match the point that humans first invaded those regions. The theory gives more credit to humans and their stone spears than to climatic changes. Caribou and bison survived mainly by having irregular migration patterns to confound the hunters. (Even more recently, the bison suffered a precipitous decline, from predation from both Asian (misnamed "native" Americans) and European immigrants). The African megafauna survived per-

haps by co-evolving with humanity, but the animals on other continents were taken by surprise, hence the "blitzkrieg".

Bridge [6.2.5] A land isthmus between two continents used for terrestrial migrations when not flooded. There are three bridges in the game: Panama, Beringia, and Spain. Migrations north through Panama during the Pliocene include porcupines, anteaters, armadillos, glyptodonts, and Cebid monkeys.

Browse [7.2.9] This game distinguishes between animals that graze and those that browse. Low plants have made themselves more and more indigestible, while the high tree foliage remains more succulent. Browsing requires a long neck, arms, tongue, or trunk to reach these high leaves. Or strength, elephants will knock a tree over to get a few leaves at the top. Browsers, such as elephants and rhinos, exhibit higher intelligence than grazers.

Carbon Dioxide The Earth's atmosphere is mainly oxygen and nitrogen, and carbon dioxide gas (CO₂) forms a very minor part. Nevertheless, this percentage is vital for plant growth, and for regulation of the planet's temperature through the greenhouse effect. Carbon dioxide is scrubbed from the atmosphere by rainfall, which produces carbonic acid, which may turn into carbonates given the proper rocks. This effect chills the planet. But carbon dioxide thus sequestered in the rocks is eventually subducted into the Earth and released into the atmosphere by volcanoes, thus completing the CO₂ cycle.

Catastrophe [6.2] Controversy continues whether the major factors in the survival or extinction of life on Earth is catastrophic or gradual in nature.

Climax [2.3.2, 5.1.4, 6.4] A mature stable plant community representing the culmination of ecological or evolutionary succession. A condition of equilibrium under prevailing ecological conditions. In this game, all biomes are rated on a climax scale from 1 to 99.

Coral Reefs Corals are not common in Mesozoic America, (most deposits are in Europe) but some reefs were built by California and Alaska coasts. Coral reefs are confined to within 30° latitude of the equator, their fossil presence in present polar regions was a prime factor in the confirmation of plate tectonics.

Cretaceous-Tertiary Boundary Event [7.3.4] Abbreviated K-T event, marked by a massive extinction rates at or near the Cretaceous-Tertiary boundary 66 million years ago, as the extreme greenhouse plummeted. On the land, the dinosaurs and pterosaurs died. In the oceans, the rudistids (coral-like oysters), great sea reptiles and lizards, ammonites and armored squid, and much plankton went extinct forever. Small, generalized, and cold-blooded animals, like fish, turtles, insects, crocodiles, seemed totally unaffected, as did plants (even the recently evolved angiosperms). Small warm-blooded animals like mammals and birds not only survived but radiated spectacularly. Possible causes of this disaster include an asteroid strike, the drop in sea level as the weed-choked American epic seaway drained off, or the Deccan traps, all of which are in the game.

Culling [6.1.7] Reduction of population/biomass due to overcrowding.

Deccan Traps A huge volcanic event at the end of the Cretaceous in India, which may have been responsible for the iridium-enriched layer in Cretaceous rocks and/or the dinosaur extinctions. This cataclysmic basaltic eruption (conceivably associated with a bolide impact in the manner of a lunar mare) may have had a severe impact upon the climate.

Dentition [2.4.1] The arrangement and form of teeth, coded **r** for reptile teeth, and **m** for mammal teeth in this game. Reptiles have unspecialized uniform teeth, that are continuously replaced as they are lost. (In camosaurus, they are curved, flattened, & serrated for cutting off chunks rather than grabbing.) Mammals have four kinds of teeth: incisors for biting and cropping, canines for holding prey, premolars for crushing, and molars for chewing. In saber toothed cats, the canines are enlarged for a peculiar pinch and slash biting action. The canines are absent or much reduced in most herbivores, which usually have a gap called the diastema between their biting and chewing teeth. Mammals have two sets of teeth: milk teeth and permanent teeth. Both types are finely sculpted to fit together precisely in a bite, compared to the dinosaur's rather sloppy bite with replaceable arrays. The life span of mammals is limited by tooth wear, and the ever-growing teeth of the dinosaurs may have contributed to their enormous size. In this game, genotypes with minimal dental formulae are favored for meat-eating, on the "snatch and gulp" or "slashing cookie-cutter" techniques of predation. Genotypes with long dental formulae (like **mm-fff**) have the extra teeth required to process low energy high fiber vegetation.

Digitigrade Walking on the tips of the toes, in the manner of dogs, cats, and camosaurus, rather than on the "flat" of the hand/foot (plantigrade, like humans). Some swift digitigrade animals (the ungulates) bear a thickened hoof and reduced number of toes; this is called unguligrade. Camels have modified this pattern by dropping back down to walk on the entire underside of their splayed digits, cushioned by a pad. This assists traversing sandy deserts.

Dinosaurs An archosaur vertebrate group close to crocodiles but showing some birdlike features in the hips and hind legs. This allowed bipedal sprinting and gallops given the more vertical posture than the splayed-out limbs typical of turtles and lizards. Dinosaurs likely inherited a warm-blooded oxidative metabolism, free of the limitations of lactic acid build-up that bedevils the fermentive metabolism of reptiles. (This may explain why there are no lizard-sized or smaller dinosaurs.) Dinosaurs arose from a semi-bipedal thecodont in the Mid to Late Triassic, and went extinct at the end of the Cretaceous.

DNA [2.5.3] Deoxyribonucleic acid, the genetic material in the nuclei of cells that contains the genetic code. DNA is coded A, T, C, G, H, I, M, N, P, S, or W in this game, see the "DNA" mapsheet chart. The dominant DNA in an allele is indicated by the use of a DNA counter.

Feathers Scales modified to insulate an animal's body by trapping a layer of air (air is the best insulating material). In this game, feathers are adaptations for insulation or solar-radiation protection rather than for flight, and feathers are more efficient than fur for this. (Granting their user a "PP" DNA.) On the other hand, feathers preclude the use of sweat glands, and thus thermoregulation involves alternate methods like panting. Feathers require bathing and preening to keep from getting matted or infested with parasites. And when they wear out, they must be replaced periodically, unlike fur, which is ever-growing.

Gala The conjecture that life regulates conditions on Earth to keep it habitable in the face of hostile abiotic and astrophysical events, due to feedback mechanisms. This game is Gaian in that players control (to a point) some of the effects of Milankovitch cycles, etc.

Generalized Organisms which few specific adaptations to the niche. A generalized beast resembles its archetype, and, in game terms, has few DNA counters. More conservative animals seem to fare better in mass extinctions than fast speciating (possibly over-specialized) species.

Genetic Drift [6.5.5] In small populations, rare or recessed alleles may not be passed on. This loss of variability is called genetic drift. Despite this, small in-bred populations exhibit enhanced variations. This is the engine of change, adaptively guided by natural selection.

Genotype [2.5.2] A population of individuals sharing a specified genetic makeup, in this game, an order or suborder of related animals. Each player is allowed four genotype populations, including its archetype. Genotypes maintain heritage characteristics even as they alter their form in response to a habitat. "Classic" ecomorph solutions that have arisen again and again include giraffe-like browsers and tank-like grazers with facial armor. Such ecomorphs have arisen independently in American omithischian dinosaurs, camels, & rhinos, and South American litopterns & marsupials. Giant "ground sloth" browsers, where a big animal stands on two feet and hooks branches with claws, is another common reoccurring ecomorph (but without living examples today).

Graze [7.2.10] Grass, a wind-pollinated gymnosperm, appeared during the Oligocene after the age of dinosaurs. Grass is adapted to discourage grazers, being intensely fibrous, and containing spicules of silica that are like needles of glass. Yet, grass seems to thrive even when continuously cropped. In order to obtain an adequate diet, grazers must repetitively munch and grind the grass, and all this mind-numbing masticating dominates the grazer's daily routines.

Greenhouse Effect [6.3.1] Solar radiation travels through space as short-wave radiation. After it strikes the Earth, the hot objects re-radiate this energy as long-wave radiation to cool off. A balance is struck, the difference between the light energy intercepted, and that lost by re-radiation back into space by the warmed planet, gives the ambient temperature. But it so happens that some gases, called greenhouse gases (carbon dioxide, water, sulfur dioxide, methane) let short-wave radiation in, but trap long-wave radiation from escaping out. Heat comes in but it can't get out, and the Earth turns into an oven, eventually melting the ice-caps and flooding the lowlands. The interior of an automobile sitting in a sunny parking lot exhibits the greenhouse effect, as ordinary window glass also readily admits short-wave sunlight, but absorbs quite a bit of long-wave radiation trying to get back out. The Greenhouse Table in the game reflects the amount of greenhouse gases in the atmosphere, and is directly proportional to the sea level as well as temperature.

Gymnosperms Non-flowering seed plants, such as conifers and cycads, which dominated the Mesozoic plant world. As the game starts, the gymnosperms are rapidly displacing the pteridophytes in the tree and shrub biomes, and the age of dinosaurs is also called the age of cycads as a result. (Cycads resemble palm trees, but are related to the archetype of pine trees.)

Hand Size [5.3.4] The number of cards in a player's hand, which are a player's recessive cards, cannot exceed the number of genotypes he has.

Heritage DNA [2.3.3, 5.2.3] In this game, innate genotype characteristics that is encoded on the genotype cards, rather than appended by DNA cards and counters. So, primates have a "PP" heritage, reflecting their big brains, but can have wings, humps, spines, etc., each giving them non-heritage DNA.

Homoiothermy Animals that maintain a constant body temperature despite ambient temperatures. All the genotypes in this game are assumed to be large enough to exhibit homoiothermy by virtue of their large thermal mass. Except for turtles and crocodiles, most would have a rather high body temperature (~38°C), and an elevated metabolism is presumed.

Horse Latitudes [6.4.1] The latitudes at 30° have high stationary air pressure, due to the descending desiccated air of the circum-global Hadley cell. This prevents prevailing winds from carrying rainwater from the oceans, and indeed most of today's great deserts are located in the horse latitudes in each hemisphere.

Huskers [6.6] Animals adapted to crack the husk of mast.

Hypoxia [6.1.9] Starvation of oxygen.

Ice Ages [6.3.4] There were ice sheets over much of the Southern Hemisphere during the Permian, but by the beginning of the game, these had retreated due to a greenhouse effect. This left global temperatures, sea level, and rainfall similar to today's levels. Further into the Mesozoic, the world got very hot and wet, and greenhouse, photosynthesis, and sea levels were at an all time high during the Cretaceous. Equatorial temperatures were slightly higher than today, but polar temperatures were 40-60° C higher, too warm for ice-caps. Indeed, large-eyed dinosaurs like allosaurs lived in Gingko forests within the Arctic and Antarctic circles. During the Tertiary, by the end of the Eocene, the climate got much wetter than today, but still warm, until a rapid oscillatory period of ice ages set in during the Quaternary. Humans live in a very transitory interlude between ice ages.

Ice-Sheets [3.3.4, 5.5.6] Widespread glacial ice.

Immigrants [2.3.6, 6.5] The isolation of the American continent makes it vulnerable whenever a land bridge forms. Foreign invaders can find this land a paradise, as the naive native plants and prey are not adapted to their specific attack modes, and the indigenous predators have not co-evolved to meet their defenses. And disease also disrupts the status quo, recall what happened when native Americans first met the more cosmopolitan Europeans (harboring antibodies & pathogens accumulated from around the world). America has suffered episodes of wholesale extinctions in the face of foreign invasions, (although not to the extremes that Australia, Spain, & South America have suffered).

Intelligence Genotypes with a ratio of brain to body mass of 1/1000 or better are awarded a P heritage, and primates and dolphins (1/100 ratios) achieved two P. Using this measure of IQ, carnivores have better brain mass ratios than herbivores, (it takes more upstairs to feed on animals than it does plants), and mammals and birds seem generally brainier than dinosaurs, reptiles, and fish. Tyrannosaurus, for example, with the same mass brain as a baboon (200 gm), had a brain ratio of 1/25,000. An exceptionally dull mammal, (Coryphodon) has a 90 gm brain in a 500 kg body for a 1/5500 ratio.

Lek A lek is a sexual arena, where males congregate to perform their courtship displays, and females make their choice. This system works well for monogamous species whose offspring need a lot of parental effort, like birds (and humans?).

Mast [6.6.3] A general term for fallen seeds edible only by huskers, animals such as sparrows and mice specialized in seed-cracking. Certain biomes, as marked on their cards, contain mast, available to those with H DNA.

Megafauna Large vertebrate animals of 100 kg (220 lb.) or more.

Migration [6.3] The movement of organisms from one location to another. This may be periodic or seasonal (as in birds) or may be a displacement in response to climatic change or hardship (as in plants). The *American Megafauna* migration rate is based upon the migration distances of size three American animals like bison and caribou, which migrate only 2500 km annually.

Milankovitch Cycles [6.1] The Earth's climate is affected by periodic oscillations in its orbit, in three grand cycles. For instance, its orbit is slightly non-circular about the sun. Gravitational nudges from other planets modulate the eccentricity of the Earth's orbit on 100,000 and 450,000 year cycles, these are the Milankovitch E cycles. This will reapportion the annual solar energy to different parts of the year. The closest approach to the sun currently happens to occur when the northern hemisphere is tilted away from the sun, that is, during the northern winter. Over a time of 21,700 years, the Earth precesses about a fixed point like a toy gyroscope, this is the P cycle. This affects the equator more than the poles, and affects the seasonality (difference in temperature between poles and equator) that drives the world's winds and weather. The Earth is currently tilted 23° from a line perpendicular to the plane of its orbit about the sun. Tugs from other planets change the Earth's tilt (from 21° to 25°) on 41,000 year cycles, this is the T cycle. A greater tilt affects the poles more than the equator, increasing, for instance, the midnight sun. And it affects, again, the seasonality.

Mountain Building Slots [2.2.5, 5.1.4, 6.3.3] Slots where the Earth's crust is prone to deformation, also called diastrophism. Certain biomes (Orogeny biomes) are restricted to these slots.

Niche Competition [5.7.2, 5.7.5] The role of a species within the community, defined in terms of its resource requirements. The overarching rule in ecology is that niches are exclusive. No two species can long exploit the same resource at the same time, as the more efficient exploiter will eventually prevail. See the Timeline sheet for a summary of Niche Competition rules for carnivores and herbivores.

Omnivore [6.7] Omnivores are defined in this game as an animal order containing both predators and herbivores, but can be conveniently thought of as a species that eats both leaves and flesh. Because of the variability of the mammal's teeth, and the non-specialized nature of their genotypes, only they can be omnivores in this game. Even members of the mammalian order *Carnivora* (dogs, cats, bears), will happily eat vegetable matter if needed. On the other hand, it is rare to find leaf-eating birds, and the dinosaurs are conveniently grouped into plant-eating (bird hipped) and meat-eating (lizard hipped) orders, with very rare crossovers.

Orogeny [2.2.5] Orogeny refers to mountain building processes (colorfully referred to as "episodes" or "revolutions" by geologists), and Orogeny biomes are those cards that grow mountains on mountain-building slots. The Cordilleran Orogeny (or "Geosyncline") was a series of disturbances resulting in the uplift of the Rocky Mountains and the formation of the Sierra Nevada and Coastal Ranges. At the beginning of the game, all of the world's continents have crashed together to form the super-continent of Pangea. This collision caused the Hercynian Orogeny, including the Appalachians between Africa and America, and later between South and North America. This high freshly-formed range prevented the prevailing easterlies from reaching the interior of the American continent. Large areas of the continent remained dry enough in the Appalachian "rain-shadow" for desert sandstone to form, and to evaporate the hypersaline central seaway repeatedly.

Pandemic [6.2.4] Widespread disease of species-killing potential.

Pangea [2.2.1] During the Triassic, at the dawn of this game, all the major continents were locked into a super-continent called Pangea. At 210 million years ago, rifts appeared as North America and Europe ("Laurasia") split from South America and Africa, and sea water poured into these seafloor spreading zones of the new Atlantic Ocean. At 85 million years ago, an extension of the Atlantic would temporarily open between North America and Europe. This is situation depicted on the map.

Permian Extinctions [7.3.1] The most severe mass extinction known, in which 96% of species went extinct. Both land and sea biomes were hit, and plants as well. The game starts in the immediate aftermath of this holocaust, and allows the proto-mammals to set up last since they had the initial upper hand, particularly in the herbivore niche. Possible causes of the Permian extinction include an asteroid strike, or the Siberian Traps.

Phenotype The product of the interaction between the genotype and the environment, the observable characters of the organism.

Plate Tectonics The world's surface is divided into relatively rigid plates that creep around, driven by forces from the circulating plastic mantle deep within. The continent of Laurentia (ancient America) is but a froth of low density granite (low density compared to the basaltic plate it is floating on), buffeted by the San Andreas subduction zone which periodically wrinkles its western coast and slams it into other continental plates.

Predator Triangle [2.2.4, 5.3.3] Triangular region in each map hex where counters are placed to show they are meat-eating. "Predator" is used as a synonym for carnivore (meat-eating) in this game.

Rain-Shadow [5.1.6] See Orogeny.

Recessive Cards [5.2.5] Genes (or latent genotypes) that produce no observable effect on the organism's phenotype. All recessive cards are kept in a player's hand, and are not inheritable (in this game).

Ruminants [7.1.7] Herbivorous mammals with a system of foregut digestion adapted to increase the efficiency of extracting protein from low food-value vegetation. It involves chewing the partly digested food ("the cud") before swallowing it again for more digestion processing in the foregut. Ruminants have a complicated multi-vat stomach, three chambered in camels and four chambered in deer, cattle, etc. Chewing the cud improves efficiency, but cannot digest as much food at a time as non-ruminants with a simple single large stomach, such as horses and zebras.

Sea Level [6.2.3] At the start of the game, sea levels were close to present levels, with a shallow continental shelf a few tens of kilometers off American shores. But sea levels rose dramatically during the Jurassic, reaching a peak in the Cretaceous. The warm epeiric seas formed over what is now the midwest were hospitable to life. Sea levels dropped again during the Tertiary, and during the Pleistocene ice ages the sea level dropped repeatedly to about 150 meters below present levels. The sea level rebounded whenever the ice-sheets retreated during interglacial warmings, and released their frozen water.

Sex Cards [5.2.7] Sex is the intermingling of genetic material like DNA. There are four 'sex' DNA head cards in the game (head-butting, trombone bugling, courtship, and leks); each of them doubles the number of genes that a player obtains if a biome or catastrophe card comes up. These cards encompass a variety of sexual intimidations, advertisements, and displays.

Siberian Traps The Ural mountains were formed at the start of this game, when Europe crashed into Angaraland, and a couple of million cubic kilometers of molten basalt were erupted over the next 600,000 years. It is conjectured that the carbon dioxide thus formed could have raised the greenhouse effect. The resulting reduced temperature differential between poles and equator made the ocean currents sluggish and reduced the rate which the oceans absorb oxygen, and circulate oxygen into the depths. Lack of oxygen (marine hypoxia) is the main mass killer of fish today, and may have caused the massive Permian extinctions.

Supernova [6.2.2] Life-damaging dosages of X-ray and ultraviolet radiation from an exploding giant star are expected to occur every 10 million years or so (two turns). However, the Earth's magnetic field should protect its biota from harm, unless it is undergoing one of its irregular reversals. It turns out that the north pole sometimes switches to the south pole, and vice versa, and while this field reverses its field strength collapses. The simultaneous occurrence of both

accidents could result in severe "starbum", particularly for plants and animals without protective fur or feathers.

Thecodonts [7.3.1] Early archosaurian reptiles, rather like crocodiles, with dentition set in jaw sockets. One of the thecodonts was the archetype of the dinosaurs. Thecodonts include the aetosaurs, phytosaurs, rauisuchians, erythrosuchians (crimson crocs), & ornithosuchians (rabbit crocs).

Therapsids [7.3.1] An order of mammal-like reptiles, the archetype of mammals. Therapsids dominated for 40 million years until the rise of the dinosaurs. Includes the dicynodonts (two-tusked) and cynodonts (dog-faces).

Triassic Extinctions [7.3.2] At the dawn of the Jurassic 200 million years ago, the therapsids like the dog-faces and two-tusked went extinct, as did the thecodonts. In the ocean, the ammonites and early ichthyosaurs also lost most of their families. Yet the dinosaurs were hardly affected. There was a 10 km asteroid strike in eastern Quebec at this time. If this was implicated in these extinctions, it is curious that this event devastated the proto-mammals yet spared the dinosaurs.

Trophic Level [5.3] A nutritional hierarchy of life with top carnivores occupying the apex or highest trophic level, feeding on (in this game) herbivores, who feed upon the lowest trophic level, energy-producing plants. See biomass to see how the passage of energy between each trophic level affects the populations within each level.

Ungulate Mammals whose feet are modified into hooves. Most are large and herbivorous, yet the ungulates derived from generalized carnivore stock during the Early Paleocene. During this post-holocaust radiation of the mammals, a surviving archosaur, the "panzerroc" *Pristichampsus*, also evolved hoof-like claws and long running legs. This armored terrestrial crocodile may have chased dawn horses that ventured too close to wetland areas. Hoofed dinosaurs included the larger horned ceratopsians and the sauropods. The most successful ungulates today are the ruminants.

Victory condition [6.8] Survive with the most population.

Zechstein [2.2.2] A shallow sea which repeatedly covered parts of Europe, rich in Euro-Boreal ammonites. As the game starts in the Triassic, the Zechstein represents an arm of the Western Tethys Sea. By the Jurassic a great spreading rift between Africa and North America joined the Zechstein and became the North Atlantic Ocean, splitting the supercontinent of Pangea into two. By the Cretaceous, a spreading zone from the Zechstein would temporarily separate Greenland and Europe from the rest of North America.

7.4 BIBLIOGRAPHY

This game has evolved. Businesses, rulesbook drafts, life forms, and in fact any system with feedback and heritage are similar in this regard. The original system had no auction, cards were dealt to players like most conventional card games. Catastrophes wiped out random genotypes with the roll of a die. The game had no differences between mammals and dinosaurs. With the decision to go diceless came the concept of dentition and other tie-breakers. Originally the niche for all biomes was population, which made for a very fluid situation. The usual tactics were to build up forces and blitzkrieg like any "Risk" or "Civilization" game. The following sources were used in this game's evolution:

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American Megafauna SOLITAIRE

Version: September 22, 1997



S.1 OVERVIEW This single player game uses all Advanced Game rules (as modified below), as if the five **biome** cards (see S.2) are five hexes. Treat the area above each of the five cards as the **predator triangle**. Each biome can vary in **biomass** from one to four; if it goes to zero it is removed as extinct.

S.2 SETUP The map is not used. Instead choose five pink biome cards and arrange them in a vertical column.

- Pick your own Physiology sheet (but do not choose the crimson croc).
- Place a population counter on one of the five biomes that has **biome requirements** of "none".
- Start at size one, and with five genes. Fifty-one cards are placed on the timeline per 3.2.

S.3 SEQUENCE OF PLAY Same as Advanced Game, 4.0.

S.4 CARD AUCTION All **genotype** and **DNA** cards cost three genes if the player chooses to buy them.

S.5 BIOME PLACEMENT Each new biome is placed upon top of the lowest **climax** biome, unless that new biome is a lower climax than the lowest of the five, making it extinct upon arrival.

- New **orogeny** cards are placed over the lowest climax orogeny card in the column, if any are present.
- There is no displacement.

S.6 GENOTYPES If a genotype is not purchased by the player, it is introduced into the game as if an **immigrant** with **dentition rrrr**, per S.7 below. Such non-player genotypes go to the maximum size allowed by their card (or by their prey, if a predator). They first check all five hexes to see if they are suitable for the biomes (vegetarians), and then, if not suitable, check all five as predators.

- Genotypes and immigrants do not attempt to compete with other non-player immigrants or genotypes.
- Non-player genotypes appearing in the Mesozoic Era use the ruling reptile side, those appearing in the Cenozoic use the mammal side.
- Genotypes check hexes from south to north if there is any ice present. If no ice present, check from north to south.

S.7 IMMIGRANTS Immigrants check the biomes and are placed as per rules (from the north if Asian, from the south if South American or Atlantic). Those with a single tooth dentition try for predator slots, those with six teeth try for herbivore slots, per 6.5.3.

- **AMPHIBIANS** Genotypes or immigrants with exactly one M DNA are called **amphibians**; they can exploit both land and marine biomes (if they meet the DNA requirements). However, genotypes with no M DNA are restricted to non-marine biomes (carnivore or herbivore), and those with two or more M DNA are restricted to marine biomes.

S.8 GREENHOUSE If the **greenhouse** goes up due to a **catastrophe**, find the lowest available climax pink marine biome card, and use it to cover up the most southern non-marine card in the column. Then remove the most southern ice-sheet, if any. If the greenhouse goes down, find the lowest climax pink ice-sheet biome card, and use it to cover the most northern non-ice biome. Then remove the most northern marine biome, if any (even if this leaves an "empty" slot). There are no other greenhouse effects or migrations.

S.9 OTHER CATASTROPHES **Pandemics** are ignored unless the player has no genes; **bridges** are always ignored. There are no biome migrations or post-migration climax, nor wet or dry latitudes. **Milankovitch cycles** occur per 6.1.1 when genotype cards are expressed (either by the player or by the system), per map or the following charts:

MILANKOVITCH E CYCLE



LAND WETTER: Wet biomes up one; dry biomes down one.

COLD CURRENTS: Cold current biomes up one; warm current biomes down one.



LAND DRIER: Dry biomes up one; wet biomes down one.

WARM CURRENTS: Warm current biomes up one; cold current biomes down one.

MILANKOVITCH T CYCLE



EROSION: All **orogeny** biomes down one in biomass.

MARINE HYPOXIA (suffocation): All marine biomes down one.



LAND MORE SEASONAL: All seasonal biomes up one.

MARINE BLOOM (upwelling): All marine biomes up one.

MILANKOVITCH P CYCLE



LAND DRIER: Dry biomes up one; wet biomes down one.



LAND WETTER: Wet biomes up one; dry biomes down one.

S.10 VICTORY CONDITIONS A player wins by surviving the 51 turns with at least one genotype.

INTRODUCTORY 2 PLAYER GAME MARSUPIALS versus HORROR BIRDS

Read This First to Learn How to Play AMERICAN MEGAFUNA!

A. OBJECTIVE: One player is the pouched marsupials, the other the birds. The winner is the player with the most population counters by the time of the last epoch card.

B. HISTORY: Although the great Cretaceous event destroyed the dinosaurs, the surviving marsupials and birds were hardly affected, and each radiated into a large variety of forms to fill the vacant eco-niches, in competition with each other.

1. **BIRDS** One of the survivor groups from the dinosaur dynasty were the *gruiformes* birds, represented today by cranes and coots. Flightless ground *gruiformes* called Diatrymids seized the top predator (or possibly herbivore) role in the Paleocene, other smaller flying *gruiformes* were fish eaters, scavengers, and herbivores.

2. **MARSUPIALS** From the mammal dynasty were the *didelphid* marsupials, the most primitive of the pouched mammals. Although surviving today chiefly in Australia, the earliest marsupials originated in North America and rapidly diversified into a variety of ecomorphs, including marsupial bears, tigers, & sloths. Although the marsupials went extinct in America, one hardy *genus*, the Virginia Opossum, re-invaded from South America via the Panama land bridge 2 million years ago.

C. MAP SET UP: Obtain the deck of pink cards and shuffle.

1. **ARCTIC SET-UP** Find the yellow card labeled "lichen tundra" and put it into one of the two slots in the "Beringia" hex (see 2.2.3). Find the yellow card labeled "ferns, sphagnum moss" and put it into one of the two slots in the "Greenland" hex.

2. **DNA DECK CREATION** One person turns over the top card, and looks in the top left corner. If it is a DNA card, (either head, guts, or limbs) place it in a separate stack. If it is an genotype, catastrophe, or immigrant card, put into a discard pile. If it is a biome card, it is put on the map (in an empty slot, where a slot is a card-shaped rectangle within one of the map's eleven hexes) per the next paragraph. Then the next card is turned over, and treated the same way. Stop drawing cards when the map is full (there are no more empty slots).

3. **LATITUDE** Biome cards are placed onto the map according to the latitude (hex row) specified in the upper left corner of the card. See 2.2.6 for a description of the map's four latitudes.

4. **SLOTS** Each map hex has two slots. Biome cards are placed into the first empty slot, starting with the furthest south, and reading right to left (west to east). If all the slots are filled within a latitude, then the card is discarded.

5. **LOWLAND BIOMES** Some biomes (the marine ones) specify lowland biomes, these are restricted to slots within hexes labeled "lowland hex".

6. **MOUNTAIN BUILDING BIOMES** Some biomes are restricted to the five slots containing "mountain building" triangles.

7. **ANY LATITUDE** Some "cosmopolitan" biomes (like grasses) are unrestricted as to latitude. These are put into the first available slot, as defined in "SLOTS" above.

8. **DNA CARD SELECTION.** At the moment the last slot of the map is filled, the marsupial player may examine the pile of DNA cards and select one to put on his sheet. Then the bird player selects two. Each DNA card is encoded with one or more letters listed in its upper right corner. The card chosen should have a letter or letters that match or exceed the requirement letter on one or more biome cards on the map, see D2 below.

DNA cards with "a", "H", "W", or "sex" are not in play. NOTE: Only DNA cards that have a "size range" that includes 1 or 2 may be selected. For instance, the "trunk" DNA shown in 2.3.4 has a size range of 2-4.

9. Holding slots, predator triangles, Greenhouse level, Milankovitch cycles, & migration arrows are not used.

D. SET UP: Obtain about 30-40 pennies or coins.

1. The marsupial player gets the Physiology sheet labeled "Opossum". He puts a population counter (with the letters

"mmm" on it) on the number one size of the top row. The "Horror Bird" player does the same with a "rrrr" counter.

2. Each player, starting with the marsupial, takes another population counter & puts it on one of the biome cards on the map whose requirement letter matches the DNA card he has selected (See "card diagram" on the Possum or Bird Sheets, or see 5.5.3 & 5.5.4).

EXAMPLE: The biome "sedge tundra" has the requirement letter "G". If the bird player has chosen a "G" DNA card, then he may place his counter on this biome. If a biome says "BG", then the bird needs both a B and a G.

NOTE: If a biome has NO requirements (the upper right corner says "none"), then either player (or both) can place population counters there.

3. Give each player five coins; these represent genes and are put somewhere on their Physiology sheet.

4. From the remaining pile of unused Pink cards, deal out 14 cards, face down, in a pile. These represent the 14 epochs of the Cenozoic era, from 66 million years ago to today.

E. TURN ONE, REVEAL EPOCH CARD The top card in the pile is turned over. Look in the upper left corner to see which of five kinds of cards it is:

1. **Biome Card** Each player is awarded one gene coin, and the card is placed on the map in the latitude specified. Since there are no empty slots, find the eligible biome with the **LOWEST climax** number (the number in the lower right corner, see card diagram). If this climax is lower than the new biome's card climax, replace it with the new biome. Otherwise, there is no effect, the new biome is extinct.

2. **DNA Card** These cards are auctioned off as described in the rules under 5.1.2. The two players use gene coins as currency during this auction, & the birds win any ties in bidding. Players may not bid unless their size is within the range specified on the DNA card.

3. **Immigrant Card** Treat these cards as "no event" as they are not used in this Introductory Game.

4. **Genotype Card** These cards are also not used. For a more advanced game, they can be auctioned off like DNA cards, and expressed per 5.2.3.

5. **Catastrophe Card** Give each player five coins. In this Introductory Game, there is no further effect.

F. TURN ONE, EXPRESS DNA CARDS Each DNA card purchased is placed upon the player's Physiology sheet along with the player's starting DNA card, in the region (head, guts or limbs) specified. Players are allowed to have only two DNA cards in each of the three regions (head, guts, limbs). If they buy a third card in a category, they must throw away one.

• Unlike the Basic Game, players hold no cards in their hand.

G. TURN ONE, SIZE ADJUST Each player (starting with the marsupial) may move their counter up or down one step on the size track of their Physiology sheet. Size can vary from one to six. If this size is outside the "size range" specified on any DNA cards he has, then that DNA card must be discarded.

H. TURN ONE, POPULATION EXPANSION Each player puts another population counter on each biome that he occupies. Each player has unlimited population counters.

I. TURN ONE, MIGRATION Each player (starting with the marsupial) may move any or all of his population counters to a biome card on an adjacent hex, or up to 2 hexes if size 3 or more.

J. TURN ONE, NICHE COMPETITION Any population counters on the map that exceed the stacking of two counters per biome card, or do not meet the biome requirements, are removed. If birds and marsupials are competing for the same biome, examine the "Niche" callout on the biome card (see card diagram), the player with the most DNA of this sort wins. If the "Niche" is "size", then the biggest player wins.

1. The marsupials win all ties in **niche competition**.

2. If a player loses all population counters, he goes extinct.

GO TO THE NEXT TURN, UNTIL ALL 14 CARDS ARE PLAYED.
THE WINNER IS THE PLAYER WITH THE MOST POPULATION.

American Megafauna Ecological Lessons

Rick Heli, Phil Vogt, Phil Eklund

Grow a Nice Tree.

Think as your archetype as the root to a nice, rounded tree that you want to build and buy cards accordingly. Genotypes are like main branches, DNA are like leaves. Try to buy some DNA early so that other genotypes have something to inherit, but don't overdo it or you'll over-specialize (see next tip). Genotypes are generally more valuable than DNA cards because they give you more flexibility and more DNA. But don't buy only genotypes or else you'll have a bunch of bare branches without leaves and it will cost you more to fit them all out with DNA without free inheritance. Ideally, by the end of the game, you should have four creatures with some minimum shared DNA, but all looking substantially different and none over-specialized. (Almost impossible if more than two players, or in the Advanced game).

Don't Get Greedy (or, the "Bolide Bash").

An over-specialized creature is one which is so loaded with DNA that you can barely read the card. Such a creature has a lot of ability to survive, but in the Advanced game the penalty for such super-specialization is the ultimate one - outright termination! - if the proper Catastrophe should drop in. During the Mesozoic Era, there is a 23% chance that any creature with purchased DNA of more than 3 of any of A, a, B, G, or S and/or triple S dies from "comet smite"! During the Cenozoic, an asteroid kills anything with more than 2 of A, a, N or S and/or triple B (the "Roadrunner Crusher"). Another Cenozoic catastrophe (supernova) kills those having more than 4 of A, a, H, I, M and S or having either double I or double N. Yet another (solar flare) kills anything bigger than size 4 or triple A or triple a. The following genotypes are at risk from these events: carnosaurs, deinonychosaurs, ostrich dinosaurs, horned dinosaurs, pangolins, ratites, and seabirds. You may choose to live dangerously and hope that these catastrophes don't appear in your game, but we recommend waiting until the Cenozoic when the chances decrease (to a 17% risk).

Don't Overspend.

Just like super-specialization, the penalties for overspending can be severe. If you have the fewest genes, there are 2 Catastrophes in the Mesozoic and 2 in the Cenozoic which force you to kill off a genotype. Even worse, have few genes means you opponent can pick up cards for next to nothing. When bidding you should always examine the card not only from your point of view, but from that of the other player. What will he do with such a card and how much will that be worth to him? Will it let him add just 2 counters or is it more like 10? How high is the climax of the biomes in question? Knowing this should tell you something about how much he intends to bid and you can bid up accordingly. If he doesn't see it and you don't need the card, you may want to point out its value to him! Even if you don't need the card, you need to make sure your opponent pays full value or else buy it yourself and just hold it.

The "Roadrunner Effect".

Genotype or DNA cards with N, S, or a, which tend to make a herbivore uncatchable, are colloquially called "roadrunner cards", named after that legendary ruling-reptile cartoon character that is always being chased by that mammalian hero Wile E. Coyote. Roadrunner cards hurt predators but only temporarily hurt your herbivore competitors (see next tip). In the meantime you have wasted precious genes you should have been using to acquire another B or an H which will help you survive as biomes rapidly change from underneath you. What DNA cards should herbivores buy? Examination of the second column in Table 7.2.3 shows the most valuable card is H, followed by B and G, followed by M and P, followed by I.

Predator's Dilemma.

The top predator controls the game (in "game warden" fashion), and as such he should try to buy roadrunner DNA and genotypes that come up. But what if a herbivore gets one, say a turtle genotype, which the carnivore cannot eat? Suddenly, wherever the turtle goes, there is a metastable situation: if the predator stays, the animal he cannot eat proliferates, and if he goes away, the native herbivore that he can eat wins. Only to disappear if the predator returns and turtles are still around. Obviously a carnivore must retreat rapidly from a roadrunner, trying to isolate its spread. If there is a refuge (like a biome where an edible herbivore has a niche that the turtle does not have), the carnivore should go there. Barring this, he may have to switch to being a herbivore. (Never forget this option, as crazy as it seems).

The 60 Ton Wiener Dog.

Gratuitous size changes may inconvenience a predator, but you may find yourself unable to adapt in time to a changing situation. For example, your biome changes out from under you. You need to play a

new DNA card to adapt, but you can't because it is limited to sizes 2-4 and you're at size 6. It takes 2 turns to change size, but you have only one, so you're dead. Or at least at risk to losing your investment to genetic drift (which has a 10.5% chance of occurring every turn). Size three is about ideal for migration rate, and expression of DNA.

The Streak.

An interesting technique is to buy Speed for your archetype, then spawn off a genotype which may well be the only creature which can predate on it. As long as you can keep more S on your herbivore and predator than players with lower dentition, or keep all the S out of other player hands, you can double your population. Because the same DNA is used for both herbivore and predator, this is much easier to do with Speed than with Armor/Anti-armor. It can be done with the Nocturnal DNA as well. Warning: See "Don't Get Greedy" for the dangers of holding too many of these roadrunner cards.

Sex and Death.

If you can get it early enough (during the Early Cretaceous at the latest), the Sex DNA is worth about 8 genes, but probably no more. In general, it is more important to watch the ratios between gene pool totals than the subtractive difference. For example, the difference between your having 11 genes and the other player having 16 (ratio of 16:11 or about 1.45) is a lot less serious than your having 1 and his having 6 (ratio 6:1). Unless something happens, in the latter case you automatically lose the next 4 auctions whereas in the former, after one or two auctions, parity will return.

Metronome of Evolution.

The game follows Bakker in assuming that thecodonts and therapsids came from a warm-blooded stock, and thus all the dinosaurs as well as mammals are warm-blooded. If the dinosaurs had low metabolisms, how could they beat the proto-mammals so badly in the Triassic. How could the pterosaurs fly without a lively body clock? How come the little mammals could not grow and out-perform the cold-blooded ruling reptiles through out the Mesozoic? The ease of size changes in the game emphasizes that small yet efficient creatures cannot be kept suppressed by large ones.

Warm-blooded Monsters.

By "warm-blooded", three things are implied: that a constant body temperature is maintained (homeothermy), that this temperature is fairly high (avian/mammal levels), and that this temperature is maintained by a high metabolism. Not all three of these things need be true, the dinosaurs could have had a unique combination that would help explain their gigantism, vulnerability, and conservatism.

Republican Dinosaurs.

Yes, conservatism. I find the dinosaurs strangely undiverse. How else could you explain how a whole category of animals could die in one swipe? Certainly no other group of animals can be so cleanly divided into plant-eaters and meat-eaters. Why did the dinosaurs never invade the oceans, nor evolve really small forms? Birds, mammals, and reptiles had no problems evolving aquatic penguins, seals, and mosasaurs, or diminutive hummingbirds, shrews, or lizards. And where are the burrowing, arboreal or flying (other than pterosaurs), hopping, or swimming dinosaurs? This is the real dinosaur puzzle.

Experimental "Cold-Blood" Start.

If you believe that the dinosaurs had cold blood and poor stamina, then try this rule: Limit all the non-avian ruling reptiles to zero N and zero S and zero sex, and remove the S and N from all non-avian non-insect genotypes & immigrants (except for one S for the pterosaurs). To reflect the vastly lower calorie requirements of cold-bloods, allow the non-avian ruling reptiles to have TWO predators for every herbivore, and TWO herbivores for every biome biomass. Cold-bloods have a maximum migration of one (pterosaur two), and are not allowed in any hex adjacent to a hex or zone with an ice-sheet. Acquiring double P or more will switch genotypes to warm-blooded rules.

Experimental Specialized Start.

As a final experiment, players may try starting with specialized early Triassic animals. The player with the most m dentition chooses one of the following heritage DNA to start with:

Rabbit Croc (rm) chooses one of the following to start with:
NP (Longisquama) Weird sail of stiff scales on back.
S (Euparkeria) Semi-bipedal.

Crimson Croc (rrrr):

AA (Erythrosuchus) Big-headed.
AM (Chasmosaurus) Crocodile-like.

Dog-Face (mmm):

AP (Cynognathus) Fur, high bite dentary.
M (Procynosuchus) Web feet & tail.
PS (Thrinaxodon) Palate, heel tendons, diaphragm.

Two-Tusker (mmrrr):

AB (Kennemeyeria) Beak & after-burning guts.
BM (Lystrosaurus) Hippo-like & after-burning guts.
G (Dicynodon) Canine tusks & after-burning guts.
N (Cistecephalus) Burrowing, max. size of one.

AMERICAN MEGAFUNA ERRATA

January 5, 1998

To agree with the upper right corner of the Timeline sheet, change the 4.1 Commentary, the 5.0 Commentary, 5.2.2, and 5.6.1, to specify that the player with the most **r** dentition, rather than the most **m** dentition, goes first. Note that the proper order of **r** dentition is: **rrrr**, **mmrrr**, **rm**, **mmm**.

3.1 (Add) In a two player game, **rm** and **mmrrr** should not play against each other, as **mmrrr** would have too great an advantage.

5.1.4 final bullet (Add): Exception: **Orogeny** and Rain-shadow [5.1.6] biomes are always placed at biomass 2.

5.2.5 RECESS CARDS (Change first sentence to read): After all expression, players may withdraw DNA Cards from their Physiology sheet to their hand.

6.3.1 (Add): Orogeny biomes do not migrate except per 6.3.3, and the rain-shadow card does not migrate except per 5.1.6.

6.5.2 (Change last two sentences to read): Each immigrant has one "wild" (W) DNA that will transform into the most suitable DNA (except H) for the requirements (or niche) of that spot per 5.2.6. A DNA counter may be placed on its card to indicate this choice. If the "W" is not needed, it is dropped and can't be used later.

6.7.1 OMNIVORES (Add): This rule should be used for the **mmm** player and not for **mmrrr** in the four player game, as otherwise the dog-face would have a disadvantage in play balance. The omnivore rule cannot be used by players who re-enter the game as immigrants per optional rule 3.6.2, however.

6.8.2 END OF THE GAME (Change first sentence): This occurs at the end of the turn after one of the following happens: ...

On the Introductory Games Sheet, and on the Solitaire Game Sheet, references to "yellow" cards should be to "green" cards. Also, "pink" cards should read "red" cards.

Introductory Game C4: Second sentence should end: "left to right (west to east)."

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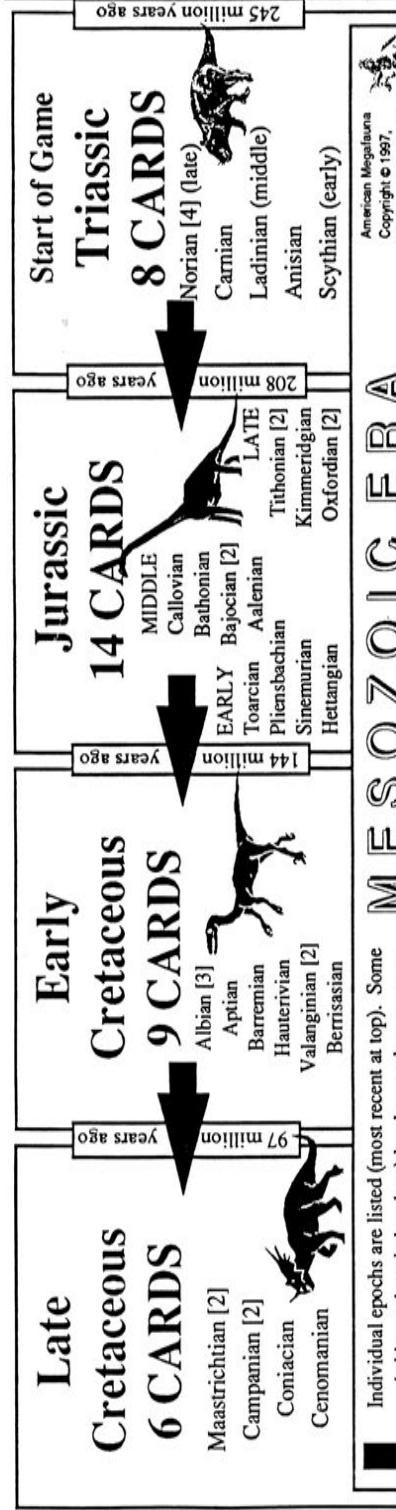
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ORDER of MAP SET-UP
r DENTITION: Archetypes with the most **r** dentition set up first.
ORDER of MOVEMENT
r DENTITION: Genotypes with the most **r** dentition move first.
ORDER of TROPHIC SELECTION
r DENTITION: Genotypes with the most **r** dentition select size & predator/prey first.



NICHE COMPETITION
Carnivore
 <Prey must be suitable.>
 1. SIZE (The biggest wins.)
 If tied:
 2. DENTITION: (Least # of teeth wins.)

PREY SUITABILITY
SIZE: The predator must not be larger than the prey, nor be more than 2 smaller.
ARMOR (DNA R or a counters): The prey must not have more armor (a) than the predator has armor-piercing (A).
SPEED (DNA S counters): The prey must not be faster (S) than the predator (S).
NOCTURNAL (DNA N counters): The prey must not have more nocturnal/burrowing (N), than the predator (N).

NICHE COMPETITION
Herbivore
 Also Husker, Fisher, and Insectivore
 <Biome must be suitable.>
 1. NICHE (The most DNA, or size, as specified by the biome niche wins.)
 If tied:
 2. PREDATOR: (Herbivores inedible to the predators present win over edible ones, or else the winner is chosen by the predator that can eat both competitors.)
 If tied (no predators or neither edible):
 3. DENTITION: (Most # of teeth wins.)

BIOME SUITABILITY
 An animal cannot utilize a biome unless it has at least the prerequisite DNA letters listed in the card's upper right corner.

GENOTYPE MIGRATION
Normal: 1 hex/epoch
Size 3 or more: 2 hex/epoch
Winged: 3 hex/epoch
Sea biome hex: If a hex has two marine biomes, it cannot be traversed without M DNA or wings.
Ice Sheet hex (Advanced Game): Cannot traverse without PP DNA or wings.
Bridge (Advanced Game): If flooded, need wings.

TURN SEQUENCE (The seven Periods in each Epoch turn)

4.1 REVEAL & AUCTION CARD An epoch card is revealed. If it is a biome card, it is played upon the map, per 5.1.4, and each player is awarded one gene. If it is a catastrophe card, each player is awarded five genes. Advanced Game: Catastrophe & immigrant cards have additional effects.

4.2 EXPRESS CARDS Each player may express cards from their hand, or recess cards from their sheet. DNA counters are placed upon genotype cards. Advanced Game: Milankovitch cycles are adjusted upon being expressed as well as the biomass of biomes with preferences.

4.3 TROPHIC LEVEL, SIZE, & HAND ADJUST Each player positions his counters to be either herbivores or carnivores and adjusts their size up to one step. If the number of cards in a hand is greater than the number of genotypes of a player, then the extra cards are discarded.

4.4 POPULATION EXPANSION Each player increases its population by one in every biome or predator triangle occupied by its genotype counters.

4.5 HERBIVORE MIGRATIONS Each player moves his herbivore counters per 5.5.

4.6 CARNIVORE MIGRATIONS & FINAL SIZE ADJUST Each player moves his predator counters per 5.6, and adjusts their size.

4.7 EXTINCTIONS Each player removes unsupported population per 5.7.1. Losers in niche competitions also remove counters. Genotypes with no population have their genotype card discarded, along with any DNA counters upon it or exclusive DNA cards.

Timeline

American Megafauna™

The Continuing Contest between Dinosaurs and Mammals

STACKING: Maximum of two biomes per hex.
LATITUDE: Biomes must be placed into a hex of the hex row specified in the upper left corner.
LAND & SEA: All marine biomes are restricted to "lowland" hexes; all orogeny biomes to mountain slots.
PLACEMENT: Biome cards are put into the hex slot containing the lowest climax biome. Empty slots count as zero climax, and southern or western slots are favored. If all available slots are filled with cards with greater climax, biome goes extinct.
DISPLACEMENT: The native biome is displaced one hex, if an empty slot is available, or else it goes extinct. If using 6.4.1, displaced biomes with a moisture preference adjust biomass when entering a wet or dry latitude.

BIOME CARD PLACEMENT

STACKING: Maximum of two biomes per hex.
LATITUDE: Biomes must be placed into a hex of the hex row specified in the upper left corner.
LAND & SEA: All marine biomes are restricted to "lowland" hexes; all orogeny biomes to mountain slots.
PLACEMENT: Biome cards are put into the hex slot containing the lowest climax biome. Empty slots count as zero climax, and southern or western slots are favored. If all available slots are filled with cards with greater climax, biome goes extinct.
DISPLACEMENT: The native biome is displaced one hex, if an empty slot is available, or else it goes extinct. If using 6.4.1, displaced biomes with a moisture preference adjust biomass when entering a wet or dry latitude.