

# **The Hanging Gardens**

## **for tuba & percussion**

### **[Just Intonation]**

**B e n   H j e r t m a n n**

**K L W H N A A   P u b l i s h i n g**



B e n H j e r t m a n n

# The Hanging Gardens

commissioned by  
**Josh Biere**

## notes about **The Hanging Gardens (2021)**

*The Hanging Gardens* is short, but challenging work for tuba and percussion.

The music is composed in Just Intonation, based on natural harmonics and related intervals. In total, there are 12 unique pitches (pitch-classes) including prime harmonics 2, 3, 5, 7, & 11. Rhythmic ratios (tuplets and tempi) relating directly to the pitch ratios are also used. Tempos corresponding to the 7th and 11th harmonics are explored in the first two thirds of the piece, respectively. Tempo-modulations (via tuplets) allow for seamless transitions between these larger sections.

At the end of the piece, the harmonic series is heard as a descending "scale" with each corresponding rhythmic subdivision in the percussion.

Of the Seven Wonders of the Ancient World, the Hanging Gardens of Babylon are the only wonder which may not have existed. Legend portrays them as enormous gardens, overflowing with scores of vegetation surrounded by desert.

The scales and melodies in this work are both familiar and other-worldly. Ancient music theorists worked with Just Intonation, and yet our knowledge of the music from distant epochs is shrouded in mystery. If the gardens existed, what chords and melodies brushed through them? The use of the percussion is melodic, overflowing and changing as it spills over the walls.

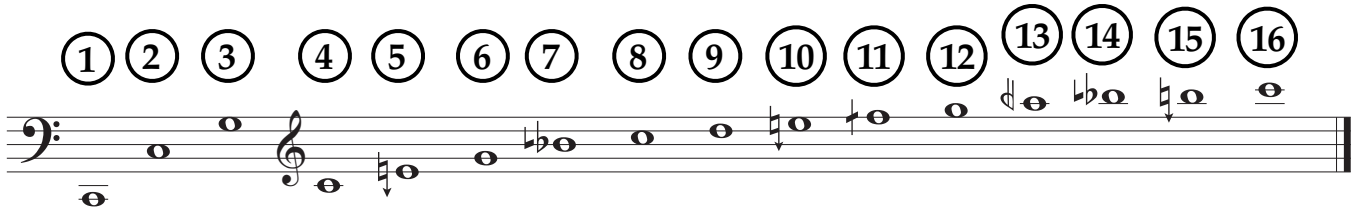
**total duration**  
**5.2 minutes**

# Introductory Notes

## Just Intonation: Introductory Concepts

### The Harmonic Series

The harmonic series is the foundation of Just Intonation. Below is the first 16 harmonics of the cello’s low C string.



The first harmonic is called the fundamental. The 2nd harmonic is two times the frequency of the fundamental. The 3rd is three times, the 7th is seven times, the 11th is 11 times, etc.

### Primes & Limits

The 2nd harmonic, and all other powers of 2 (4, 8, 16, 32, etc.) is the same “pitch class” as the fundamental. Two times the frequency of any other harmonic is an octave higher than it, etc. The octave is also the only interval that is identical in Equal Temperament and Just Intonation. Moving up the series, the even-numbered harmonics are higher octaves of pitches that have already occurred. Each prime number introduces a new pitch and interval.

This piece is in "11-Limit" meaning it harmonics with prime factors 2, 3, 5, 7, and 11. It does not 13 or higher primes.

### Pitches, Intervals, Ratios, & Fractions

Fraction-style notation [e.g., 9/8, 7/6, 4/3...] are used to denote pitches in relation to a fundamental or dyad intervals between any two pitches. They are written between 1/1 and 2/1, with the larger value on top and the bottom value octave-adjusted to be smaller than an octave. For example, 9/8 is seen instead of 9/4 or 9/2. While all these refer to the pitch of the 9th harmonic, 9/8 is octave-adjusted to its smallest size (less than an octave) by multiplying the ‘denominator’ by powers of 2. Ratios, written as harmonics separated by colons, are used to describe intervals & chords such as the 4:5:6 Major triad.

### Cents

Percentage of an equal-tempered half step. There are 100 cents per half step, 1200 per octave. Though this work is not in Equal Temperament, cents are useful for describing tuning distinctions. A pitch with a “+” or “-” followed by a number 1-99 is assumed to be a cents value. “D-33” means D-33 cents.

### Helmholtz-Ellis Accidentals

The Just accidentals used in this work are “Helmholtz-Ellis,” a system designed by Marc Sabat & Wolfgang von Schweinitz. The three accidentals used are explained below.

Normally this system uses traditional accidentals to show Just Perfect Fifths (3:2) which are 2 cents larger than equal temperament. However, for *Hanging Gardens*, these 2 cents distinctions can be rounded to Equal Temperament, because of the restricted number of 3-Limit pitches, the margin of error is only 6 cents, and the tuba valves are likely more suited to equal-temperament. So, for this piece, consider the traditional accidentals equivalent to equal-tempered (normal) pitches.

<div>5</div> <div></div> <div>(-14 cents)</div>	The arrow lowers the natural by 14 cents to show the natural tuning of the 5th harmonic. This accidental only occurs as E $\downarrow$ , as the 5th harmonic of C in the third section of the piece. (Note that E $\downarrow$ is used in the second section of the piece).
<div>7</div> <div></div> <div>(-31 cents)</div>	This symbol is added to any accidental to lower the pitch by 31 cents to show the natural tuning of the 7th harmonic.
<div>11</div> <div></div> <div>(+51 cents)</div>	This “quartertone” symbol raises the pitch by 51 cents to show the natural tuning of the 11th harmonic.

# Tuba Notes

## Tuba Pitches & Microtones

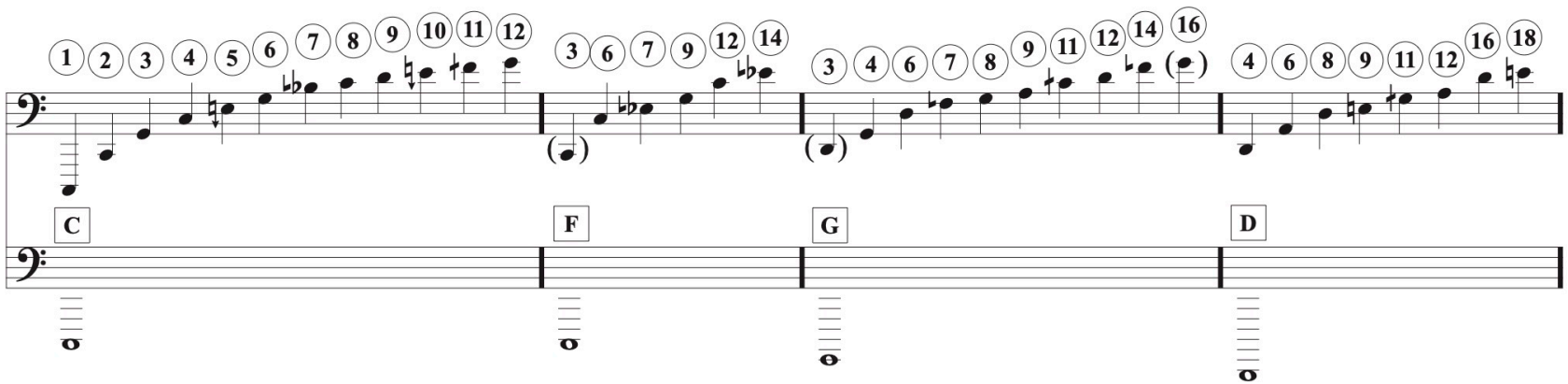
All pitches performed by the tuba in *The Hanging Gardens* are pure harmonics of four fundamentals. All microtones should be played as pure (uncorrected) harmonics, not as "lipped" / bent pitches. The scale below shows every pitch used in the piece. There are 12 pitches, but they do not align with the chromatic scale because there is no B and there are two versions of E.



There are five 2 & 3-Limit pitches: C $\flat$ , D $\flat$ , E $\flat$ , G $\flat$ , & A $\flat$ , which can be played as harmonics 1,2,3,4,6,8,12,16, & 18. There is one 5-Limit pitch: E $\sharp$  which is only played as harmonics 5 and 10 of C. There are three 7-Limit pitches: B $\flat$ , E $\flat$ , & F $\flat$ , which are only played as harmonics 7 or 14 of C, F, & G respectively. There are three 11-Limit pitches: F $\sharp$ , G $\sharp$ , & C $\sharp$ , which are only played as harmonic 11 of C, D, & G respectively.

The accidentals correspond to the prime harmonics, so the unusual accidentals show signal which harmonic to play, whereas the natural notes allow some flexibility of which fundamental / harmonic can be used.

## Tuba Fundamentals & Fingerings



Above are the four fundamentals, and thus the fingered notes for all pitches in the piece. Notice that the F fundamental is present only for its 7th harmonic. F $\sharp$  never occurs in the piece. A and E are the only pitches which could be played in other fingerings and achieve the same tuning. A & E (fundamental) fingerings may be used for these two pitches only if deemed helpful for the performer.

While certain harmonics are duplicates in a given fingering, they may be useful in a certain passage. For example, a C would usually be played as a harmonic of C, but might be played as a harmonic of F if moving to / from E $\flat$ . The precise moment of valve-fingering switch is decided by the performer.

## Tuba Range & Difficulty

This piece knowingly sits very high in the tuba's range for long periods of time. Partly, this is meant as a challenge for the fierce performer who commissioned it. More importantly, however, it is necessary to reach all the "natural" / pure harmonic tunings the piece requires. If the range proves too difficult, the piece could be performed down an equal-tempered whole step in B $\flat$  instead of C. If this option is chosen, make sure all pitches keep the exact same ranges in relation to each other and all fundamentals are adjusted accordingly. It is preferred that the entire piece is performed down a whole step rather than, for example, moving any melodic or harmonic pitch down an octave.

Contact the composer with issues and / or suggestions and a solution will be devised between composer & performer.

# Percussion Notes

**Percussion Instruments**  
"drum set" consisting of:

**Kick Drum**  
**Snare Drum**  
**Floor Tom**  
**Six Roto Toms (2 sets of 3)**  
    Two 6" for Roto5 & Roto6  
    Two 8" for Roto3 & Roto4  
    Two 10" for Roto1 & Roto2

**Perc. Notation & Key**

The percussionist reads the drum set part, but a pitched staff for the roto toms is provided below for the reference of both performers.

## Drum Set Notes

The kick drum should be relatively dead, with little to no sustain. The snare should be relatively tight (possible a piccolo), but also deadened on top and/or bottom so as not to overwhelm the other drums in volume. It should be equally balanced to the toms in volume. The floor tom may be tuned to a low C or D (below bass clef) or tuned with less-distinct pitch. It should be lower than the low G in Roto1. The floor tom may also be deadened to put its timbre/resonance in between a tom and a kick. It is used more the like the (unpitched) kick and snare than the rotos.

## Roto Tom Setup

As shown in the key above, the toms are numbered by size and pitch (see note below about Roto5 & Roto6). The roto toms should be mounted on two roto tom rack/stands, but they should ascend from low to high over all six rather than Low-Mid-High on each of the three racks. The exact placement and arrangement of the rotos is at the discretion of the percussionist, based on physical setup, preferred hands, and sticking choices.

## Roto Tom Tunings

The six roto toms are tuned as shown below. The accidentals are explained in the previous pages. Of course, it may be difficult to get the roto toms *exactly* in-tune. Try to get them as close as possible.

Roto Toms Tuning #1 (Beginning)      Roto Toms Tuning #2 (mm. 49-87)      Roto Toms Tuning #3 (mm. 87-End)

The roto toms should be set to Tuning #1 before the piece begins. They may be tuned with the tubists harmonics or with a tuning device that allows for accurate cent deviations from equal temperament. Tuning #1 appears in the drum set on corresponding lines/spaces as if it were (approximately) the same pitches in treble clef, which may be useful for learning. However, in Tunings #2 & #3, this correlation breaks down. Note that in Tunings #2 & #3 Roto5 is higher than Roto6. This is because Roto6 pitch is in common between Tuning #1 & #2.

The tunings align with the scales given in the analytical notes in the following pages. Roto3 and Roto4 remain tuned to B $\flat$  and D $\sharp$  throughout the piece.

The retunings are notated with glissando lines in the score/part. The goal pitch (or a related pitch) is often present in the tuba and/or other roto pitches at the time of retuning. The retunings happen quickly, but there should be enough time if rehearsed. If there is not enough time, the performers can insert a brief pause or repeat the tuning measure(s) until the drum is in tune. It is recommended that the percussionist mark the angles/positions of the destination pitches, which should get them close to the goal pitch with a quick turn.

## LH & RH Stickings (ad lib.)

The left and right hand stickings were rigorously planned during the composition process, however they were omitted in the end to allow for the percussionists choice. Hopefully, unnecessary arm crossings can be minimized.



# Analytical Notes

## Scales/Pitches by Section

The following scales show the pitch content for the three large sections of the piece.



The first large section of the piece (mm. 1-48) uses a 7-Limit heptatonic scale. It resembles G Aeolian and C Dorian, except with smaller 7/6 minor thirds. The characteristic 6:7:9 minor triad occurs in this scale on G, C, and D. This section explores these melodious 7-limit minor modes.

The second large section of the piece (mm. 53-87) uses an octatonic scale with a mix of 7-Limit and 11-Limit pitches and a clear tonal center of D. This is the most unusual scale, including two 12:11 (undecimal 'neutral 2nds' (150 cents) intervals, two 28:27 intervals, as well as 22:21 and 33:28. The 6:7:9 minor triad occurs in this scale D. Additionally, there are 8:9:12 "Sus" chords based on D and F♯ which play a key role in the melodic content.

Notable in the first two scales is the 28:27 ('septimal third-tone'), a small "halfstep" of only 63 cents occurring between A and B♭ in both scales. It also occurs between D and E♭ in the first scale and between E and F♭ in the second scale.

The third large section of the piece (mm. 91-140) section uses a hexatonic scale based in C. It contains only harmonics of C, including primes 1, 3, 5, 7, 9, and 11, including all harmonics 1-12 in their natural octaves.

Finally, note that B♭ and D♯ occur in all three sections/scales. In G they are 7/6 and 3/2, in D they are 14/9 and 1/1, and in C they are 7/4 and 9/8. These two pitches are also the only roto tom pitches that stay constant throughout the piece. Roto3 and Roto4 are locked to these pitches throughout.

## Tempi & Tuplets

The "fundamental tempo" of *The Hanging Gardens* is 61 beats per minute, which is equal to the dotted quarter in the first 8 measures of the piece, and is equal to the half note from measure 85 to the end. This tempo is related to the primary fundamental pitch of the piece, C. The pedal C occurring at the end in the Tuba has a frequency of 32.7 Hz. Five octaves below that C is the tempo of approximately 61 beats per minute.

The tuplets appearing in the last 8 measures of the piece (and elsewhere) are whole number multiples of that fundamental tempo. In other words, rhythmic speeds of 61 (bpm) multiplied by 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, and 12 occur. These are the same relationships that occur in the realm of pitch in the piece.

The 7-tuplet and 11-tuplet are expanded further in measures 9-28 and 49-84, respectively, via tempo-modulations.

In the 7-tempo section, dotted-8ths produce a 7:6 and triplets produce 21:16 ratios from the overall fundamental, relating to the E♭ and F♭, in the realm of pitch, respectively.

These relationships are baked into the fabric of the piece. The 7-tempo section uses all the 7-Limit pitches and the 11-tempo section uses all the 11-Limit pitches available. However, there is not a direct pairing of pitch to rhythm except in the last 8 measures.

## Meters

The numerators of the meters correspond to the rhythmic relationships as well. The same or similar patterns occur in the tuplet versions as in the corresponding tempo sections, especially in the percussion. Note in the 21 / 16 meter, beginning in measure 17, that seven dotted-8ths form the groupings of 7\*3 while at the same time three double-dotted-quarters outline 3\*7 (heard in the percussion as Kick-Snare-Snare).

# Performance & Rehearsal Notes

<p><b>Dynamics ad lib.</b></p> <p>There are no notated dynamics in the music, except a handful of crescendi. Dynamic shaping is encouraged by both performers. The volumes of the two instruments should be equally balanced from the audiences perspective. For example, if the higher range of the tuba requires the tubist to increase volume, the percussionist should try to match the volume while keeping a fluid through-line.</p> <p>Additionally, it is recommended that the percussionist give slight extra emphasis on all downbeats of measures and beat-groups to accentuate the rhythmic feel.</p>
<p><b>Strictness of Tempi</b></p> <p>The specificity of the tempi is the product of rhythmic relationships in the piece, and the overall tempo (61 bpm) is an approximate low octave of C, the overall tonic of the piece. Keeping these tempi is preferred. However, in preparing for the best performance possible, the performers may decide to slow down the overall tempo of the piece. If this is the case, it is preferred that the <i>internal</i> relationships between the tempos are kept in tact (as per the tempo modulations). In other words, if slowing down a section, it is preferred that all sections slow down by the appropriate amount to preserve the relationships.</p>
<p><b>Tuba &amp; Percussion Quasi-Unisons</b></p> <p>The roto toms melodic content is at times loosely doubled in the tuba, creating quasi-unisons. This is not always the case, but when it is, it can be useful for coordination.</p>
<p><b>Rhythmic Challenges &amp; Repetition</b></p> <p>The rhythms in this work are challenging in scope, yet are designed to be playable and intuitive once prepared. The percussion rhythms are full, but include a lot of internal repetition.</p> <p>Performers are encouraged to practice each individual section/pattern on their own first, then combine them in succession. Practice with the included MIDI realizations is encouraged as well, especially at the beginning of the learning process.</p>
<p><b>Tuba Rehearsal/Preparation Suggestions</b></p> <p>Many elements of this music are challenging for the tuba: range, microtones, rhythmic groupings, and more. It is recommended that the tubist familiarize themselves with the elements individually before combining them all. For example, the pure harmonics that constitute the pitch material can be prepared out of time at first.</p> <p>Practice arpeggiating the 6:7:9 "minor" triad on F and C fundamentals. Practice the sequences of 11th harmonics (as in measure 75). Practice the rhythmic groupings in 21/16 and 11/8 on a single pitch. Practice harmonics 1-12 with a C fundamental to prepare for the final section. Listen to the tempo of measure 8-29 (7-tempo) and memorize the speed which returns as 7-tuplets later in the piece. These are all merely suggestions, but may be a useful approach.</p> <p>For the metric modulations, the tubist should look at the percussionists part during rehearsal, and possibly during performance. The 11-tuplet rhythms, for example, might seem abstract on their own. However, the 11 rhythms are very similar to the 11/8 meter section in the middle of the work. Count the percussionists attacks to find the tuba</p>
<p><b>Percussion Rehearsal/Preparation Suggestions</b></p> <p>Each section contains internal repeats. Begin with each repeated section on its own. The percussion essentially is responsible for the tempo-modulations. The tempo goals may be memorized to make the transitions smooth.</p>
<p><b>Duet Rehearsal/Preparation Suggestions</b></p> <p>Try rehearsing individual measures or groups of a few measures first, then try larger sections, and lastly rehearse the transitions and put it all together.</p>



In the spirit of the Seven Titans of Illinois Wesleyan

# The Hanging Gardens

for Josh Biere

Ben Hjertmann

♩. = 61

Tuba

Perc.

(Rotos)

(2-bar pattern, repeated twice)

flowing

4

6

8

10

A ♩. = 71 (61 \* 7/6)

(4-bar pattern, repeated once)

3

3

12

12

12

15

(♩ = ♪)

B 3x7 [6+6+6+3]  
7x3 [7+7+7]

21/16

(4-bar pattern, repeated twice)

15

15

15

18

18

18

21

21

21

24

24

24

Musical score for "The Building" by John Williams. The score is in 4/4 time, key of D major, and tempo of 122. It includes measures 27 through 45, with a section labeled "D" starting at measure 35. The piano part features complex rhythmic patterns, including triplets and septuplets, while the string quartet provides harmonic support with sustained notes and moving lines.

**F** [2+2+3+2+2]

*serpentine*

(4-bar pattern, repeated once)

*strong & insistent, but not too heavy*

[illegible]

**G** [3+3+3+2]

This musical score is for the piece 'G' [3+3+3+2]. It features three staves: a top staff in bass clef, a middle staff in treble clef, and a bottom staff in bass clef. The top staff begins with a key signature of one flat (B-flat) and a common time signature. The middle staff starts at measure 61 and contains complex rhythmic patterns with many beamed notes and accents. The bottom staff also starts at measure 61 and features a more melodic line with some chromaticism. The piece concludes with a double bar line and a fermata in the top staff.

**H**

[2+2+3+2+2]

(4-bar pattern, repeated once)



65

65

69

69

69

I [3+3+3+2]

73

73

J [2+2+3+2+2]

77

(4-bar pattern, repeated once)

77

81

81

K ♩ = 122

♩ = ♩ ♯̄̄̄

85

(1-bar pattern, repeated twice)

85

[tune roto6 down 85 cents]

L

89

open and singing as from a balcony

89

full and unhindered like wind through the garden

89

[tune roto2 down 204 cents]

[tune roto1 up 294 cents]

93

93

93

97

97

97

100

100

100

104

104

104

108

112

115

119

123



127

127

127

131

131

131

135

135

135

The musical score is written for three staves. The top staff is in bass clef, the middle in alto clef, and the bottom in bass clef. The key signature has one flat (B-flat). The score is divided into measures by bar lines. Measure numbers 127, 131, and 135 are indicated at the start of their respective systems. The notation includes various note values (quarter, eighth, sixteenth, and half notes), rests, and accidentals. Fingerings are indicated by numbers 1-5. Articulation marks like accents and staccato are present. Dynamic markings include 'f' (forte) and 'p' (piano). Performance techniques such as triplets, quintuplets, and doublets are marked with brackets and numbers. Slurs are used to group notes. The score concludes with a double bar line at the end of the third system.



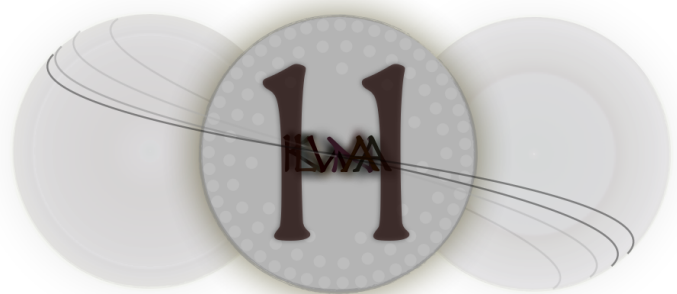
Asheville, Mars Hill

Oct. '20 – Oct. '21





**K l w h n a a   P u b l i s h i n g**



**w w w . b e n h j e r t m a n n . c o m**

