## APPENDIX 3

### MOVEMENT AND LEARNING PATTERNS OF THE UNBORN CHILD AND THE DEVELOPMENT OF THE SENSES

#### ARM MOVEMENTS

Isolated arm movements first occur.  
About 7 to 8 weeks after conception  
dev Vries (1982), p 311

Stretching an arm is frequently accompanied by extending the fingers.  
From 10th week after conception  
dev Vries (1982), p 307

#### BREATHING MOVEMENTS

First seen.  
8th week after conception  
Roodenburg, p 32

A single, large displacement of the diaphragm is sometimes similar to a sigh.  
8th week after conception  
Nijhuis/dev Vries, p 6

First seen.  
8-9 weeks after conception  
Nijhuis/dev Vries, p 5

Observed in 10 of 12 fetuses studied, with a median frequency of about 30 breathing movements per hour.  
9th week after conception  
dev Vries (1985), p 106

Observed in 12 of 12 fetuses studied, with a median frequency of about 60 breathing movements per hour.  
11th week after conception  
dev Vries (1985), p 106

The median breathing movement rate was 208 per hour in 12 fetuses studied.  
17th week after conception  
dev Vries (1985), p 105

The rate of breathing movements was much higher during the second hour after the mother’s breakfast or lunch than during the third hour.  
20th – 22nd weeks after conception  
dev Vries (1987), p 337

Breathing movements occurred most often right after the mother’s meal at noon.  
20th – 22nd weeks after conception  
dev Vries (1987), p 337
The frequency of breathing movements changes during the day. In a study of 10 fetuses, such movements increased from a median of 2% of the observation time in the morning to 13% in the afternoon, and then fell to 11% in the evening.

A significant increase in fetal breathing occurred after giving glucose to the mother.

**EMBRYOSCOPY**

Embryoscopy can directly visualize the embryo/fetus during the first trimester, paving the way to improved early prenatal diagnosis and treatment. Utilizing high-resolution fiberoptic endoscopy, testing can be done as early as 3 weeks after conception. The face can be visualized as early as 4 weeks. Numerous diagnoses have already been done but these just scratch the surface of the technology’s potential.

**EYE MOVEMENTS**

Slow eye movements first occur. 18–34 weeks after conception Nijhuis/de Vries, p 28

First seen. About 14th week after conception Inoue, p 172

First seen. 14th – 16th weeks after conception Roodenburg, p 33

In 9 fetuses studied, the median number of eye movements at 18 weeks after conception were 25 per hour, increasing to 101 per hour at 34 weeks.

Rapid eye movements first occur. 21st week after conception Nijhuis/de Vries, p 5; Birnholz, p 679
### FINGER MOVEMENTS

First occur. 10\textsuperscript{th} week after conception Nijhuis/de Vries, p 5

Opening and closing one or more fingers can be seen. 10\textsuperscript{th} week after conception Nijhuis/de Vries, p 6

### GENERAL MOVEMENTS

First occur. 6\textsuperscript{th} – 7\textsuperscript{th} weeks after conception Roodenburg, p 31

First occur. 6
- 7
weeks after conception Nijhuis/de Vries, p 5

In nine fetuses studied, there were a median of 57 general movements per hour, which were present during 24\% of the observation time. 18\textsuperscript{th} week after conception Roodenburg, p 23

### HAND-TO-FACE CONTACTS

Insertion of the fingers into the mouth has been observed. 8\textsuperscript{th} week after conception Nijhuis/de Vries, p 7

First occur. 8-10 weeks after conception Nijhuis/de Vries, p 5

The hand touches the face slowly and the fingers often open and close. 8-10 weeks after conception de Vries (1982), p 309 & p 311

Observed in 12 of 12 fetuses studied, with a median frequency of about 25 contacts per hour. 10\textsuperscript{th} week after conception de Vries (1985), p 113

In a study of 9 fetuses, the median number of hand-to-face contacts was 95 per hour. 18\textsuperscript{th} week after conception Roodenburg, p 33

### HEAD MOVEMENTS (BACKWARD)

First occur. 7
- 10
weeks after conception Nijhuis/de Vries, p 5
**HEAD MOVEMENTS (FORWARD)**

| First occur. | 8th - 12th weeks after conception | Nijhuis/de Vries, p 5 |

**HEAD ROTATIONS**

| First occur. | 7th - 10th weeks after conception | Nijhuis/de Vries, p 5 |

| Observed in 12 of 12 fetuses studied, with a median rate of about 5 head rotations per hour. | 11th week after conception | de Vries (1985), p 113 |

| In a study of 9 fetuses, the median number of head rotations was 63 per hour. | 18th week after conception | Roodenburg, p 33 |

**HEARING**

| “For at the moment the sound of your greeting reached my ears, the infant in my womb leaped for joy”. | Before birth | Luke 1: 44 |

| The fetus responds to sound. | 10th – 14th weeks after conception | Nijhuis/Hep-per, p 133 |

| “Blink-startle” responses to vibroacoustic stimulation have been observed. | 22nd & 23rd weeks after conception | Birnholz & Benacerraf, p 516 |

| The fetus apparently hears some sounds in utero. | 22nd – 24th weeks after fertilization | Williams, p 169 |

| Changes in fetal heart rate, eye blinks, and movements have occurred in response to sounds. | Not available | Nijhuis/Hep-per, p 137 |

| Evidence is growing that the fetus can hear voices in the womb. | Not available | Fifer & Moon, p 430 |

**HEART RATE**

| The heart is contracting at a rate of 40 to 80 beats per minute, as measured with an electrocardiogram. | 6th – 7th weeks after conception | Rugh, p 53 |
The fetal heart rate decreases overnight. 20th – 22nd weeks after conception de Vries (1987), p 341

The daily pattern of changes in the fetal heart rate follows the changes in the maternal heart rate. 20th-22nd weeks after conception de Vries (1987), p 345 & p 346

**HICCUPS**

First occur. 6th week after conception Roodenburg, p 32

First occur. 6th - 8th weeks after conception Nijhuis/de Vries, p 5

Observed in 12 of 12 fetuses studied, with a median frequency of about 50 hiccups per hour. 8th week after conception de Vries (1985), p 108

The frequency of hiccupping changes during the day. In a study of 10 fetuses, the median number of hiccups during 8 AM to 10 AM was 28 per hour, decreasing to 12 per hour during 1 PM to 3 PM. 20th – 22nd weeks after conception de Vries (1987), p 338

**HUMAN LIFE**

Includes the period from conception to birth. From conception to birth Nijhuis, p xix

**JAW OPENINGS**

Jaw openings first occur. 8th - 10th weeks after conception Nijhuis/de Vries, p 5

Jaw openings were observed in 10 of 12 fetuses studied with a median rate of about 18 per hour. 10th week after conception de Vries (1985), p 114

Jaw openings were observed in 12 of 12 fetuses studied with a median rate of about 30 per hour. 12th week after conception de Vries (1985), p 114
Jaw movements include isolated jaw movements, sucking, swallowing, yawning, and tongue movements. In 9 fetuses studied, the median frequency of any kind of jaw movements was 142 per hour.

The frequency of jaw openings changes during 20th – 22nd weeks after conception. In a study of 10 fetuses, the median rate was 51 per hour during 8 AM to 10 AM, increasing to 97 per hour during 1 PM to 3 PM.

**LEARNING**

Newborns stopped crying and responded to songs played on shows that their mother watched while they were pregnant.

Newborns prefer the sound of their mother’s voice when it is adjusted to resemble what was heard in the womb.

Newborns learned to change their pattern of sucking in order to hear their mother’s voice instead of that of another woman. The preference appears to have been acquired before their birth.

Newborns changed their sucking pattern in order to hear a story that had been read to them before birth instead of an unfamiliar story.

Mothers who kept the same diet before and after they gave birth were more successful in breastfeeding than mothers who changed to a less spicy diet. This may reflect the child’s preference for food she ate while she was pregnant because the mother’s milk contains clues about her diet.
### LEG MOVEMENTS

Isolated leg movements first occur.  
About 7—10 weeks after conception  
de Vries (1982), p 311

### MOVEMENTS

The technology of real-time ultrasonography can be used to detect movements such as breathing, cardiac contractions, and pulsations of the vessels.  
Before birth  
Williams, p 1023

All fetal movements ever observed by the author are similar to those seen after birth and are easily recognizable to persons familiar with movements made by preterm and full-term infants. The pattern of yawns and stretches seen in the first trimester remains the same throughout life.  
Before birth  	Nijhuis/Precht, p 65 & p 66

Fetal movement patterns are coordinated from the start and are similar to those after birth.  
Before birth  
de Vries (1985), p 100

Heart activity can be measured with transvaginal ultrasonic scanning.  
4th week after fertilization  
Williams, p 1027

Spontaneous movements, such as twitching of the trunk and limbs, have been reported.  
6th week after fertilization  
Moore, p 94

The earliest reflexes begin.  
Day 42 after conception  
Rugh, p 47

The fetus normally moves spontaneously.  
6th—8th weeks after conception  
de Vries (1982), p 318

Neck and trunk muscles start contracting spontaneously.  
7th week after fertilization  
England, p 206

Purposeful limb movements first occur.  
8th week after fertilization  
Moore, p 97

Limb movements first occur during the 8th week. By the 14th week, they become coordinated.  
8th—14th weeks after fertilization  
Moore, p 112
If the fetus is removed from the uterus, spontaneous movements may be observed. The most common movement patterns have emerged.

If the region near the mouth is stimulated, the fetus will open its mouth and suck a finger.

Reflex activity can be evoked in aborted fetuses, indicating muscular activity.

Movements begin, but are usually not felt by the mother.

The fetus responds to stimulation of the skin.

Stroking the lips causes the fetus to suck and stroking the eyelids results in a reflex response.

Slow eye movements occur.

The first day that movement is noticed by the pregnant woman is called “quickening”.

In a study of 10 fetuses, the majority of movements occurred more frequently in the afternoon and evening than in the morning.

Signs of life (i.e. quickening) are felt by the mother.

Movement is usually recognized by the mother.

Rapid eye movements begin.

**QUIESCENCE**

In a study of 12 fetuses, the longest median period of inactivity was 260 seconds.
PAIN

The fetal heart rate increases in response to scalp blood sampling and after tactile stimulation during amniocentesis, indicating that the fetus responds to stimuli that may be painful.  

The sudden burst of body movements that occurred during amniocentesis may have been caused by painful stimulation. In each patient, the needle either struck the fetus or the fetus moved against the needle.  

Pain pathways run from sensory receptors in the skin to those in the brain. Nerve endings that sense pain are at least as dense in the skin of a newborn as in an adult. Such receptors appear around the mouth in the 5th week after conception, and are present in the face, the palms, and the soles of the feet by the 9th week, spreading to the trunk, arms, and legs by the 13th week, and to all areas of the skin by the 18th week. The development of the neocortex, the largest part of the brain, begins at 6 weeks after conception, and by 18 weeks a full complement of nerve cells is present. The evidence thus suggests that by late in gestation the fetus has developed sufficiently to sense pain.

SMELL

The olfactory lobe, which is related to the sense of smell, is present in the brain. The foundation of the sense of smell is established when nerve fibers connect with the olfactory lobe in the brain.

SOMERSAULTS

The fetus can accomplish a complete change in position, usually with a backwards somersault.
**SQUINTING**

Local stimuli may evoke squinting.  
8th week after fertilization  
Williams, p 169

**STARTLES**

First occur.  
6 – 7 _ weeks after conception  
Nijhuis/de Vries, p 5

First occur.  
7th week after conception  
Roodenburg, p 33

Startles were observed in 12 of 12 fetuses studied, with a median number of about 42 per hour.  
7th week after conception  
de Vries (1985), p 104

**STRETCHES**

First occur.  
8th week after conception  
Roodenburg, p 33

First occur.  
8 _ - 13 _ weeks after conception  
Nijhuis/de Vries, p 5

In a study of 9 fetuses, the median number of stretches were 6 per hour.  
18th week after conception  
Roodenburg, p 28

**SUCKING**

First occurs.  
10 _ - 12 _ weeks after conception  
Nijhuis/de Vries, p 5

**SWALLOWING**

First occurs.  
10 _ - 12 _ weeks after conception  
Nijhuis/de Vries, p 5

Swallowing is evident.  
12th – 14th weeks after fertilization  
Williams, p 169
**TASTE**

The fetus has many more taste buds than a newborn. It probably has a sense of taste.  

<table>
<thead>
<tr>
<th>Event</th>
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<tr>
<td>Taste buds begin to form.</td>
<td>8&lt;sup&gt;th&lt;/sup&gt; week after conception</td>
<td>Rugh, p 53</td>
</tr>
<tr>
<td>Taste buds are evident.</td>
<td>3&lt;sup&gt;rd&lt;/sup&gt; lunar month</td>
<td>Williams, p 169</td>
</tr>
<tr>
<td>Taste buds are developing.</td>
<td>11&lt;sup&gt;th&lt;/sup&gt; – 13&lt;sup&gt;th&lt;/sup&gt; weeks after fertilization</td>
<td>Moore, p 234</td>
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A facial response occurs when the fetus is given bitter-tasting substances. Reflexes between the taste buds and facial muscles are in place.  

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<td>26&lt;sup&gt;th&lt;/sup&gt; – 28&lt;sup&gt;th&lt;/sup&gt; weeks after fertilization</td>
<td>Moore, p 234</td>
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A fetus swallowed more amniotic fluid when it was sweetened. In contrast, the fetus responded to the injection of a noxious-tasting substance into the amniotic fluid by reducing its sucking movements, possibly indicating that it did not like the taste of the substance.  

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**TONGUE MOVEMENTS**

First occur.  

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<tr>
<td>First occur.</td>
<td>9&lt;sup&gt;th&lt;/sup&gt; week after conception</td>
<td>Nijhuis/de Vries, p 5</td>
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**YAWNING**

Has been observed.  

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