Figure S1. Connectivity and mean synaptic strengths of the connections are uniform for all distances between a pair of neurons. For the X axis, positive means the receiving cell is to the right the sending cell in the slice. For the Y axis, positive means the receiving cell is above of the sending cell. For the Z axis, positive means the receiving cell is on top of the sending cell.

(A,D,G,J) Connection probability for X,Y,Z and angle between the vector connecting two neurons and the X axis separately (No significant variation, all chi square tests p>0.05). Error bars are 95% confidence intervals estimated from binomial distributions.

(B,E,H,K) Mean synaptic strengths for X,Y,Z and angle separately (No significant variation, all one-way ANOVA tests p>0.05). Error bars are standard errors of the mean.

Figure S2. The overrepresentation of bi-directionally connected pairs is not due to inhomogeneous connection probabilities for neurons of different distances. Counts relative to random are shown for neurons of different distances. The red line indicates the value calculated for pooled data for neurons of all distances. Notice that the values calculated for certain distances are very similar to that calculated for pooled data. However, the ratio (3.0) calculated for all distances is a bit lower than that calculated for the entire dataset (4.0), probably due to increased connection probability (0.013 versus 0.0116) caused possibly by inefficient recovery of totally unconnected quadruplets. Error bars are standard deviations from bootstrap.
Figure S3. Connection probability and mean synaptic connection strengths are not greatly modified by cutting.

(A) Connection probability is uniform with regard to the distance to the closest main axon cut ending (p = 0.077 by chi square test). Notable exception is distances >600µm away, where the connection probability seems to be slightly increased. However, since there are relatively few neurons with axon cut distance of more than 600µm and the increase in connection probability is not statistically significant, we do not expect this to fully explain our results.

(B) Mean synaptic connection strength does not vary systematically with regard to the distance to the closest main axon cut ending (However, mean strength depends on distance, p = 0.02 by one-way ANOVA).

(C) Histogram of neurons with certain axon cut distances.

(D) Connection probability is uniform with regard to the depth of both the neuron sending the connection and the neuron receiving the connection (p = 0.99 by chi-square test).

(E) Mean synaptic connection is uniform with regard to the depth of both the neuron sending the connection and the neuron receiving the connection (p = 0.2 by one-way ANOVA).

(F) Histogram of recorded neurons with certain depth.

Error bars in A and D are 95% confidence intervals estimated from binomial distribution. Error bars in B and E are standard errors of the mean.
Figure S4: EPSP size and rate of connectivity does not significantly depend on animal age.  
(A,B) No statistically significant difference among EPSP amplitudes for animals with different 
ages was found (one way ANOVA in log space, p=0.36). We note, however, that there is a weak 
downward trend, in agreement with the observation of [34] that L5-to-L5 synaptic strength in P28 
animals is significantly weaker than in P14 animals. Error bars are standard errors of the mean. 
(C.) The connectivity rate does not depend on animal age (chi-square test, p=0.92). Error bars are 
95% confidence intervals calculated from binomial distribution.
Figure S5: Main results of this paper are still valid for the subset of data from P14-16 days animals

(A, B) Overrepresentation of bidirectional connections and highly connected triplets. Numbers on top of bars are actual counts.

(C) Synaptic connection strengths are well fit by the lognormal distribution. Number on top of dots are actual counts (not shown when >50).

(D) Probability of significant deviation from random for a given triplet motif.

(E, F) Increase in overrepresentation of bidirectional connections and highly connected triplets for increasingly higher connection strength thresholds.
Figure S6. Quadruplet catalogue

Table S1. Quadruplet counts. Quadruplets are numbered according to the catalogue in Figure S6.

<table>
<thead>
<tr>
<th>i</th>
<th>quadruplet count</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>178 149 85 14 11 14 9 6 9 6 1 2 2 1 3 2 10 6 3</td>
</tr>
<tr>
<td>2</td>
<td>1 4 2 3 2 1 3 3 1 2 3 4 1 2 1 2 1 1 1 1</td>
</tr>
<tr>
<td>3</td>
<td>1 1 1 1 1 1 2 1 1 1 1 1 1 1 0</td>
</tr>
</tbody>
</table>
**Figure S7** Synaptic strengths of incoming and outgoing connections are weakly correlated.  
(A) Scatter plot of incoming synaptic connection strength. A weak correlation of 0.2 is observed ($p=0.029$).  
(B) Scatter plot of outgoing synaptic connection strength. A weak correlation of 0.17 is observed ($p=0.054$).  
(C) Scatter plot of outgoing and incoming synaptic connection strength. A weak correlation of 0.13 is observed ($p=0.039$). All correlations calculated using Pearson’s $R$ method in log space.

**Figure S8** EPSP standard deviation depends weakly on EPSP amplitude  
(A) EPSP standard deviation depends weakly on EPSP amplitude  
(B) Coefficient of variation is inversely proportional to the EPSP amplitude. Note the log-log scale.
Appendix S1. Properties of the lognormal distribution.

A random variable $X$ has a lognormal distribution if the random variable $Y = \ln X$ has a normal (i.e., Gaussian) distribution. We denote the distribution of $X$ by $p(x)$. If the associated normal distribution has mean $\mu$ and variance $\sigma^2$, then the lognormal distribution has distribution function $p[w] = A \exp\left[-(\ln[w] - \mu)^2/2\sigma^2\right]/w$, where $A$ is a normalization constant. It is skewed, with mean $e^{\mu + \sigma^2/2}$, median $e^\mu$, and mode $e^{\mu - \sigma^2}$ (most probable value, peak in the distribution curve). For the synaptic connection strength curve in this paper, the associated normal distribution has mean $\mu = -0.702\text{mV}$, and variance $\sigma^2 = 0.8752\text{mV}^2$. The mean, median, and mode of the lognormal distribution are respectively 0.77mV, 0.50mV, and 0.21mV. The lognormal distribution is similar in shape to power-law distributions for a wide range of values. When plotted in log–log scale the lognormal curve is close to linear in the “waist” region (see Figure 5A). The curve would be linear for a power-law distribution. This can be understood by writing

$$\ln p(x) = -\frac{(\ln x)^2}{2\sigma^2} + \left(\frac{\mu}{\sigma} - 1\right) \ln x - \ln \sqrt{2\pi} \sigma - \frac{\mu^2}{2\sigma^2}.$$

For $e^{-(\sigma^2 - \mu)} < x < e^{(\sigma^2 - \mu)}$, which in the case of the synaptic connection strength distribution is $0.21\text{ mV} < x < 4.76\text{ mV}$; contribution of the quadratic term is smaller than half of the linear term, and the lognormal distribution looks linear [74]. Because we do not have many data points for large synapses with large connection strengths, it is possible that the tail of the distribution is better fit by a power law, although the lognormal distribution does provide a quite good fit to the whole dataset.

One useful additional property of the lognormal distribution is that the product of lognormally distributed variables is again lognormally distributed. Therefore, if we divide
the synaptic strength on one day by the synaptic strength on another day, the distribution of fractional changes again obeys a lognormal distribution.

The lognormal distribution is extensively discussed in the ecology literature. The number of members of an individual species is observed to obey a lognormal distribution. The stochastic Gompertz growth model is often used to explain this phenomenon [56,59]. In this model, the following stochastic differential equation is assumed:

\[ dN(t) = aN(t) \log \left( \frac{N}{N(t)} \right) dt + \sigma N(t) dW(t), \]

where \( N(t) \) is a time-dependent random variable denoting the distribution of number of members of a particular species, and \( t \) is time. \( \bar{N} \) is the mean number of members at equilibrium. \( W(t) \) is a Wiener process (zero mean and unit variance) and models the random fluctuations in the amount of growth over time, and \( \sigma \) is the standard deviation of the fluctuations. The equilibrium distribution of \( N \) becomes lognormal:

\[ p_{\text{log}}(n) = \frac{4}{n} \exp\left(-\left(\ln n - \ln \bar{N} + \frac{\sigma^2}{2\alpha}\right)^2 / \left(\frac{\sigma^2}{\alpha}\right)\right), \]

where \( A \) is a constant to normalize the distribution function. An analogous growth equation could be used to model the synaptic connection strength studied in this paper.