In [1]:
```
import tensorflow as tf
tf.__version__
```

Out[1]:
```
'2.2.0'
```

In [1]:
```
from keras.datasets import mnist
from keras.layers import Dense, Dropout, Input
from keras.models import Model,Sequential
from keras.layers.advanced_activations import LeakyReLU
from keras.optimizers import Adam
from tqdm import tqdm
import numpy as np
import matplotlib.pyplot as plt
%matplotlib inline
# from google.colab import drive
from PIL import Image

import warnings
warnings.filterwarnings('ignore')
```

```
Using TensorFlow backend.
```

导入数据集

In [3]:
```
def load_data():
    (x_train,y_train),(_,_) = mnist.load_data()
    x_train = (x_train.astype(np.float32)-127.5)/127.5
    x_train = x_train.reshape(60000,784)
    return (x_train,y_train)

X_train,y_train = load_data()
print(X_train.shape,y_train.shape)
```

```
(60000, 784) (60000,)
```

In [4]:
```
(x,y),(_,_) = mnist.load_data()
for i in range(1,10):
    image = Image.fromarray(x[i])
    display(image)
# image = Image.fromarray(x[0])
# display(image)
```

生成器G

In [5]:
```
def build_generator():
    modelG = Sequential()

    modelG.add(Dense(units=256,input_dim=100))
    modelG.add(LeakyReLU(alpha=0.2))

    modelG.add(Dense(units=512))
    modelG.add(LeakyReLU(alpha=0.2))

    modelG.add(Dense(units=1024))
    modelG.add(LeakyReLU(alpha=0.2))

    modelG.add(Dense(units=784,activation="tanh"))
    modelG.compile(loss='binary_crossentropy',
                optimizer=Adam(0.0002,0.5))
    return modelG

generator = build_generator()
generator.summary()
```

```
Model: "sequential_1"
_________________________________________________________________
Layer (type)                 Output Shape              Param #
=================================================================
dense_1 (Dense)              (None, 256)               25856
_________________________________________________________________
leaky_re_lu_1 (LeakyReLU)    (None, 256)               0
_________________________________________________________________
dense_2 (Dense)              (None, 512)               131584
_________________________________________________________________
leaky_re_lu_2 (LeakyReLU)    (None, 512)               0
_________________________________________________________________
dense_3 (Dense)              (None, 1024)              525312
_________________________________________________________________
leaky_re_lu_3 (LeakyReLU)    (None, 1024)              0
_________________________________________________________________
dense_4 (Dense)              (None, 784)               803600
=================================================================
Total params: 1,486,352
Trainable params: 1,486,352
Non-trainable params: 0
_________________________________________________________________
```

分类器D

In [6]:
```
def build_discriminator():
    modelD = Sequential()

    modelD.add(Dense(units=1024,input_dim=784))
    modelD.add(LeakyReLU(alpha=0.2))
    modelD.add(Dropout(0.3))

    modelD.add(Dense(units=512))
    modelD.add(LeakyReLU(alpha=0.2))
    modelD.add(Dropout(0.3))

    modelD.add(Dense(units=256))
```

```
    modelD.add(LeakyReLU(alpha=0.2))
    modelD.add(Dropout(0.3))

    modelD.add(Dense(units=1,activation='sigmoid'))

    modelD.compile(loss='binary_crossentropy',
                   optimizer=Adam(0.0002,0.5))
    return modelD

discriminator = build_discriminator()
discriminator.summary()
```

```
Model: "sequential_2"
_________________________________________________________________
Layer (type)                 Output Shape              Param #
=================================================================
dense_5 (Dense)              (None, 1024)              803840
_________________________________________________________________
leaky_re_lu_4 (LeakyReLU)    (None, 1024)              0
_________________________________________________________________
dropout_1 (Dropout)          (None, 1024)              0
_________________________________________________________________
dense_6 (Dense)              (None, 512)               524800
_________________________________________________________________
leaky_re_lu_5 (LeakyReLU)    (None, 512)               0
_________________________________________________________________
dropout_2 (Dropout)          (None, 512)               0
_________________________________________________________________
dense_7 (Dense)              (None, 256)               131328
_________________________________________________________________
leaky_re_lu_6 (LeakyReLU)    (None, 256)               0
_________________________________________________________________
dropout_3 (Dropout)          (None, 256)               0
_________________________________________________________________
dense_8 (Dense)              (None, 1)                 257
=================================================================
Total params: 1,460,225
Trainable params: 1,460,225
Non-trainable params: 0
_________________________________________________________________
```

建立GAN网络

In [7]:

```
def build_GAN(modelD,modelG):
    modelD.trainable = False
    GAN_input = Input(shape=(100,))
    x = modelG(GAN_input)
    GAN_output = modelD(x)
    GAN = Model(inputs=GAN_input,outputs=GAN_output)
    GAN.compile(loss='binary_crossentropy',optimizer=Adam(0.0002,0.5))
    return GAN

GAN = build_GAN(discriminator,generator)
GAN.summary()
```

```
Model: "model_1"
_________________________________________________________________
Layer (type)                 Output Shape              Param #
=================================================================
input_1 (InputLayer)         (None, 100)               0
_________________________________________________________________
sequential_1 (Sequential)    (None, 784)               1486352
_________________________________________________________________
sequential_2 (Sequential)    (None, 1)                 1460225
=================================================================
```

```
Total params: 2,946,577
Trainable params: 1,486,352
Non-trainable params: 1,460,225
_________________________________________________________________
```

绘图

In [8]:

```
def draw_images(generator, epoch, examples=25, dim=(5,5), figsize=(10,10)):
    noise = np.random.normal(loc=0,scale=1,size=[examples,100])
    generated_images = generator.predict(noise)
    generated_images = generated_images.reshape(examples,28,28)
    plt.figure(figsize=figsize)
    for i in range(generated_images.shape[0]):
        plt.subplot(dim[0],dim[1],i+1)
        plt.imshow(generated_images[i],interpolation='nearest',cmap='Greys')
        plt.axis('off')
    plt.tight_layout()
    plt.savefig('outputMnist/Generated_images %d.png' %epoch)
```

训练

In [9]:

```
def train_GAN(epochs=1,batch_size=128):
    X_train,y_train = load_data()
    generator = build_generator()
    discriminator = build_discriminator()
    GAN = build_GAN(discriminator,generator)

    for i in range(1,epochs+1):
        print("Epoch %d" %i)

        for _ in tqdm(range(batch_size)):
            noise = np.random.normal(0,1,(batch_size,100))
            fake_images = generator.predict(noise)

            real_images = X_train[np.random.randint(0,X_train.shape[0],batch_

            label_fake = np.zeros(batch_size)
            label_real = np.ones(batch_size)

            X = np.concatenate([fake_images,real_images])
            y = np.concatenate([label_fake,label_real])

            discriminator.trainable=True
            discriminator.train_on_batch(X,y)

            discriminator.trainable=False
            GAN.train_on_batch(noise,label_real)

        if i==1 or i%10==0:
            draw_images(generator,i)

train_GAN(epochs=200,batch_size=128)
```

```
Epoch 1
100%|██████████| 128/128 [00:04<00:00, 27.81it/s]
Epoch 2
100%|██████████| 128/128 [00:02<00:00, 50.06it/s]
Epoch 3
100%|██████████| 128/128 [00:02<00:00, 50.75it/s]
```

```
Epoch 4
100%|██████████| 128/128 [00:02<00:00, 51.13it/s]
Epoch 5
100%|██████████| 128/128 [00:02<00:00, 50.35it/s]
Epoch 6
100%|██████████| 128/128 [00:02<00:00, 48.38it/s]
Epoch 7
100%|██████████| 128/128 [00:02<00:00, 50.85it/s]
Epoch 8
100%|██████████| 128/128 [00:02<00:00, 51.01it/s]
Epoch 9
100%|██████████| 128/128 [00:02<00:00, 49.68it/s]
Epoch 10
100%|██████████| 128/128 [00:01<00:00, 70.74it/s]
Epoch 11
100%|██████████| 128/128 [00:02<00:00, 55.12it/s]
Epoch 12
100%|██████████| 128/128 [00:02<00:00, 50.68it/s]
Epoch 13
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Epoch 14
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Epoch 15
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Epoch 16
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Epoch 17
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Epoch 18
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Epoch 19
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Epoch 20
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Epoch 21
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Epoch 22
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Epoch 23
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Epoch 24
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Epoch 25
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Epoch 26
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Epoch 27
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Epoch 28
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Epoch 29
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Epoch 30
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Epoch 31
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Epoch 32
100%|██████████| 128/128 [00:02<00:00, 53.11it/s]
Epoch 33
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Epoch 34
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Epoch 36
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Epoch 37
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Epoch 39
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Epoch 40
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Epoch 41
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Epoch 43
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Epoch 70
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Epoch 75
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Epoch 76
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Epoch 80
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Epoch 82
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Epoch 89
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Epoch 90
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Epoch 91
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Epoch 92
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```
Epoch 93
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Epoch 94
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Epoch 99
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Epoch 100
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Epoch 122
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Epoch 123
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Epoch 138
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Epoch 140
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Epoch 143
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Epoch 144
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Epoch 145
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Epoch 146
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Epoch 147
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Epoch 148
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Epoch 151
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Epoch 152

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Epoch 153
100%|██████████| 128/128 [00:02<00:00, 49.16it/s]
Epoch 154
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Epoch 155
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Epoch 156
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Epoch 157
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Epoch 158
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Epoch 159
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Epoch 160
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Epoch 161
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Epoch 162
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Epoch 163
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Epoch 164
100%|██████████| 128/128 [00:02<00:00, 50.12it/s]
Epoch 165
100%|██████████| 128/128 [00:02<00:00, 51.76it/s]
Epoch 166
100%|██████████| 128/128 [00:02<00:00, 50.87it/s]
Epoch 167
100%|██████████| 128/128 [00:02<00:00, 49.78it/s]
Epoch 168
100%|██████████| 128/128 [00:02<00:00, 49.88it/s]
Epoch 169
100%|██████████| 128/128 [00:02<00:00, 50.17it/s]
Epoch 170
100%|██████████| 128/128 [00:02<00:00, 50.42it/s]
Epoch 171
100%|██████████| 128/128 [00:02<00:00, 51.87it/s]
Epoch 172
100%|██████████| 128/128 [00:02<00:00, 51.00it/s]
Epoch 173
100%|██████████| 128/128 [00:02<00:00, 52.44it/s]
Epoch 174
100%|██████████| 128/128 [00:02<00:00, 51.56it/s]
Epoch 175
100%|██████████| 128/128 [00:02<00:00, 51.06it/s]
Epoch 176
100%|██████████| 128/128 [00:02<00:00, 50.39it/s]
Epoch 177
100%|██████████| 128/128 [00:02<00:00, 51.82it/s]
Epoch 178
100%|██████████| 128/128 [00:02<00:00, 50.58it/s]
Epoch 179
100%|██████████| 128/128 [00:02<00:00, 50.76it/s]
Epoch 180
100%|██████████| 128/128 [00:02<00:00, 50.71it/s]
Epoch 181
100%|██████████| 128/128 [00:02<00:00, 54.89it/s]

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Epoch 182
100%|██████████| 128/128 [00:02<00:00, 53.66it/s]
Epoch 183
100%|██████████| 128/128 [00:02<00:00, 51.31it/s]
Epoch 184
100%|██████████| 128/128 [00:02<00:00, 52.09it/s]
Epoch 185
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Epoch 186
100%|██████████| 128/128 [00:02<00:00, 52.10it/s]
Epoch 187
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Epoch 188
100%|██████████| 128/128 [00:02<00:00, 51.22it/s]
Epoch 189
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Epoch 190
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100%|██████████| 128/128 [00:02<00:00, 55.00it/s]
Epoch 193
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Epoch 194
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Epoch 195
100%|██████████| 128/128 [00:02<00:00, 49.95it/s]
Epoch 196
100%|██████████| 128/128 [00:02<00:00, 51.80it/s]
Epoch 197
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Epoch 198
100%|██████████| 128/128 [00:02<00:00, 50.66it/s]
Epoch 199
100%|██████████| 128/128 [00:02<00:00, 51.04it/s]
Epoch 200
100%|██████████| 128/128 [00:02<00:00, 51.14it/s]
/home/zouzh/anaconda3/envs/tensorflow-GPU/lib/python3.6/site-packages/ipykern
el_launcher.py:5: RuntimeWarning: More than 20 figures have been opened. Figu
res created through the pyplot interface (`matplotlib.pyplot.figure`) are ret
ained until explicitly closed and may consume too much memory. (To control th
is warning, see the rcParam `figure.max_open_warning`).
  """
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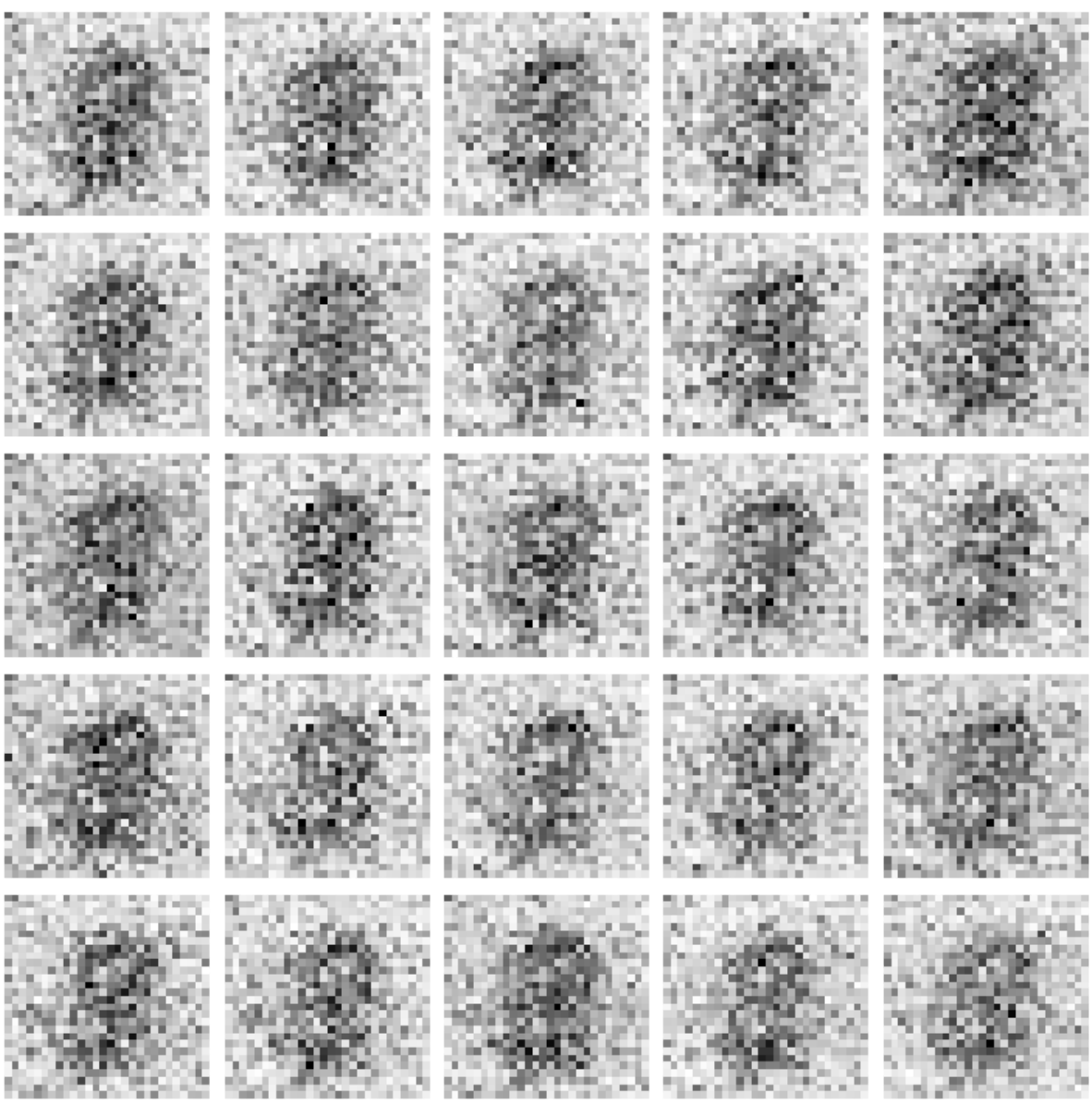

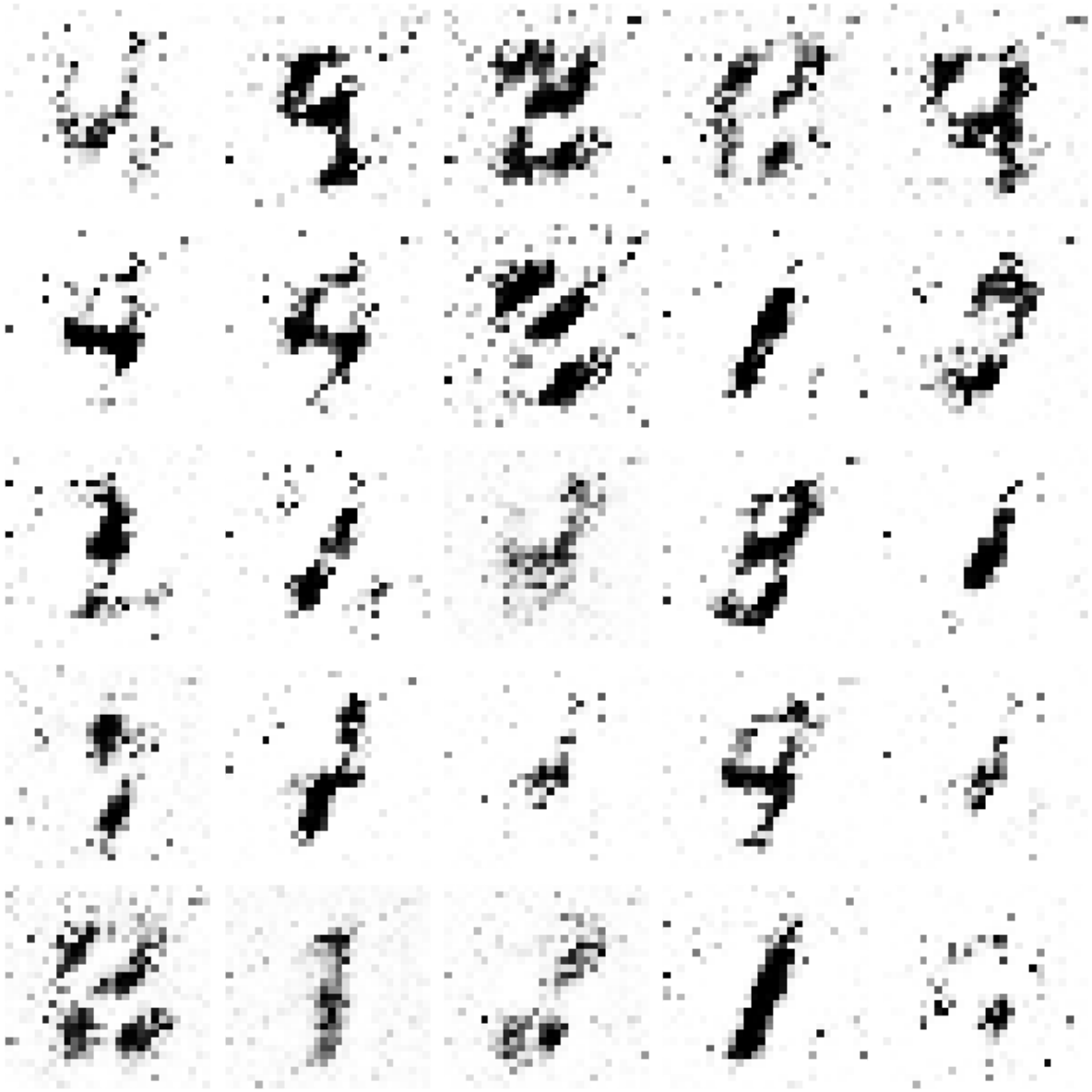

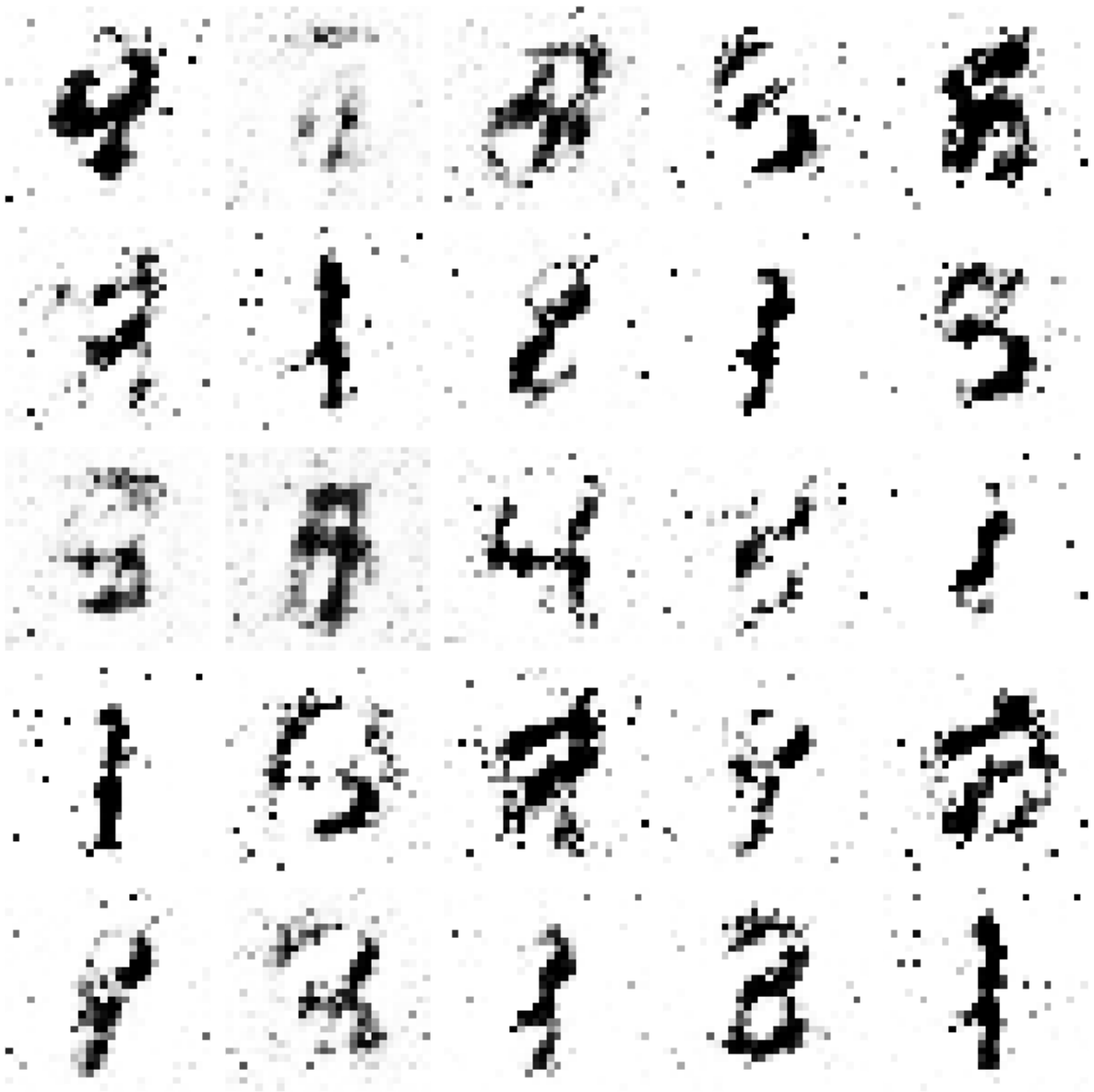

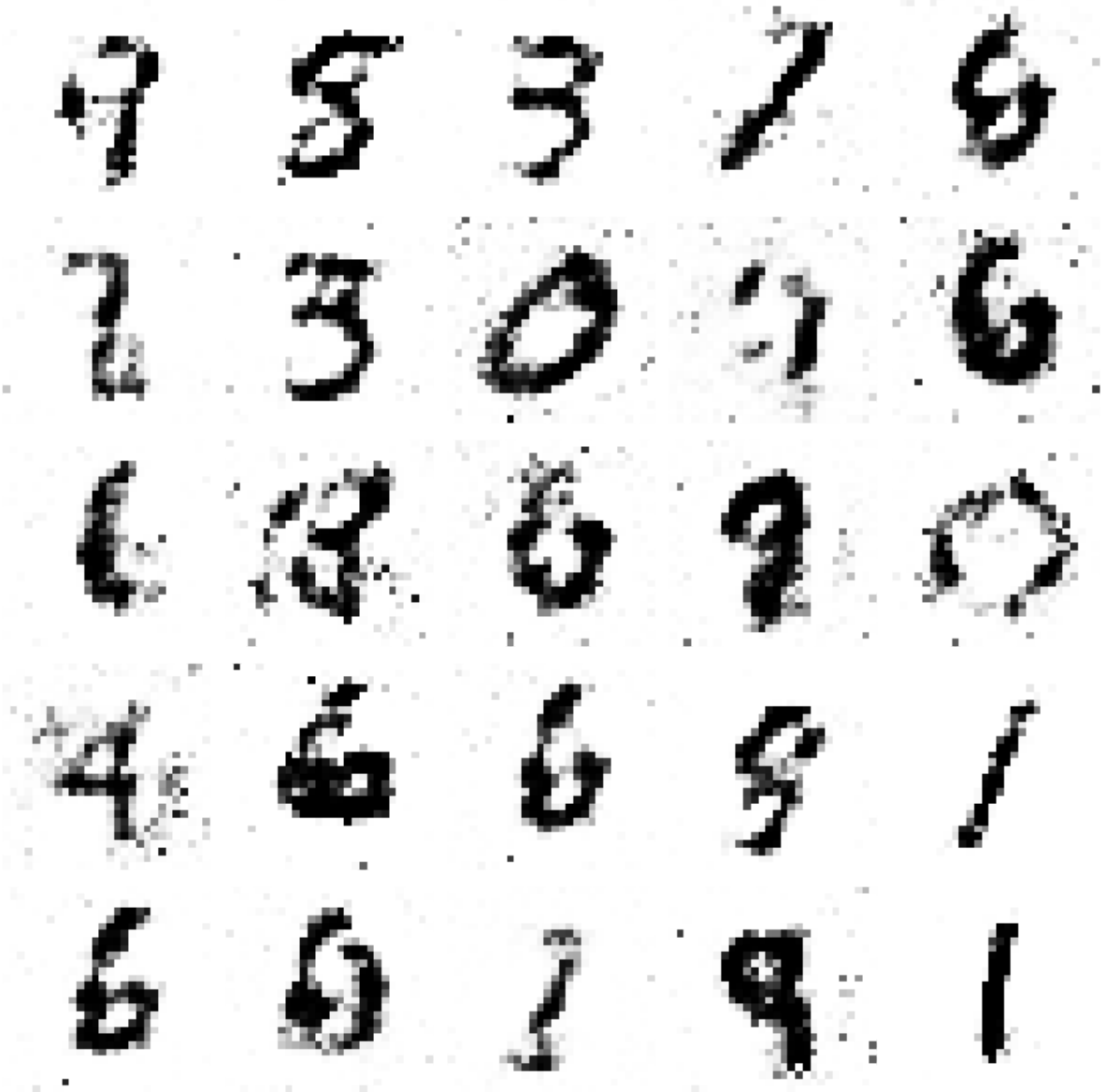

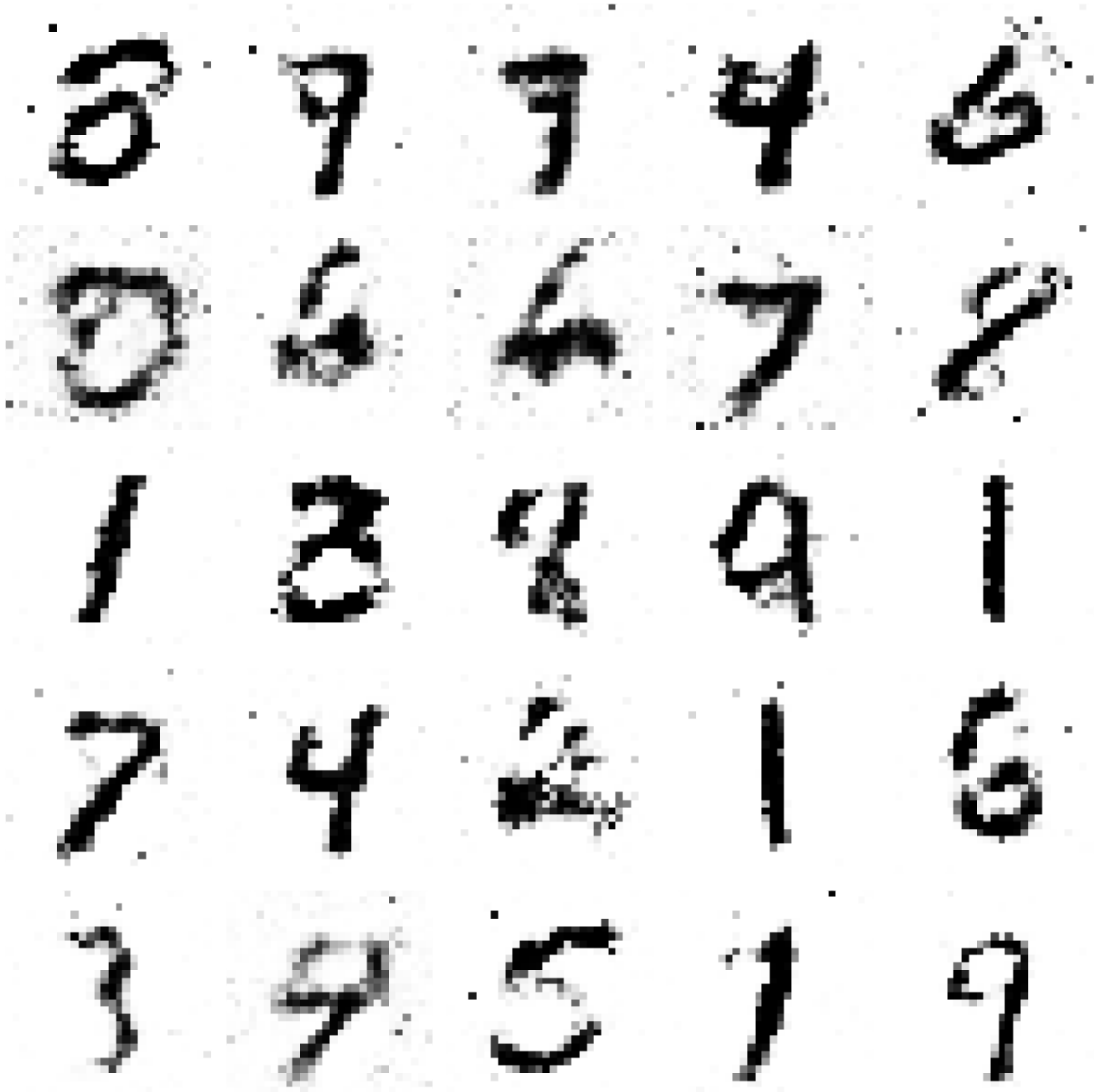

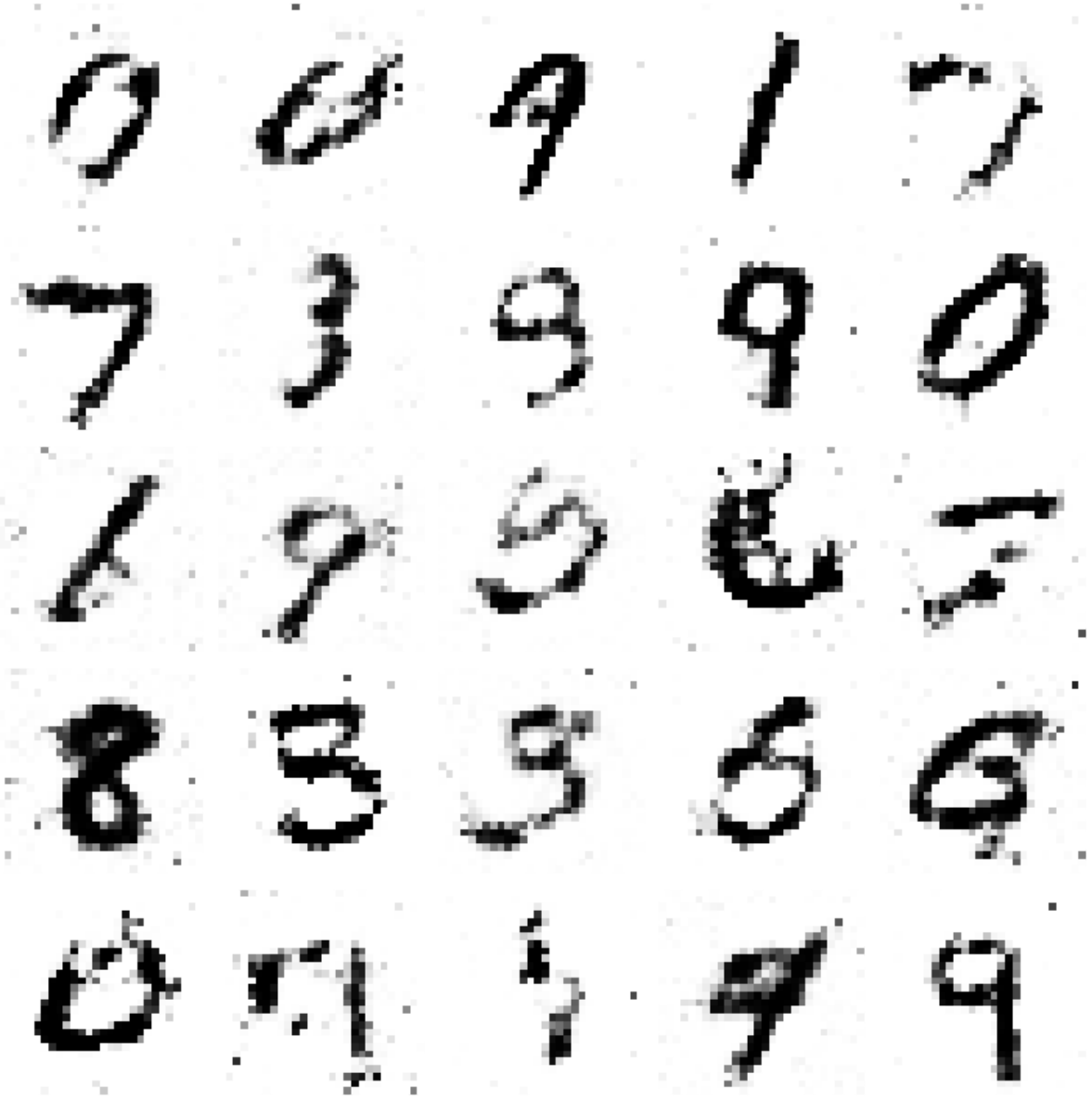

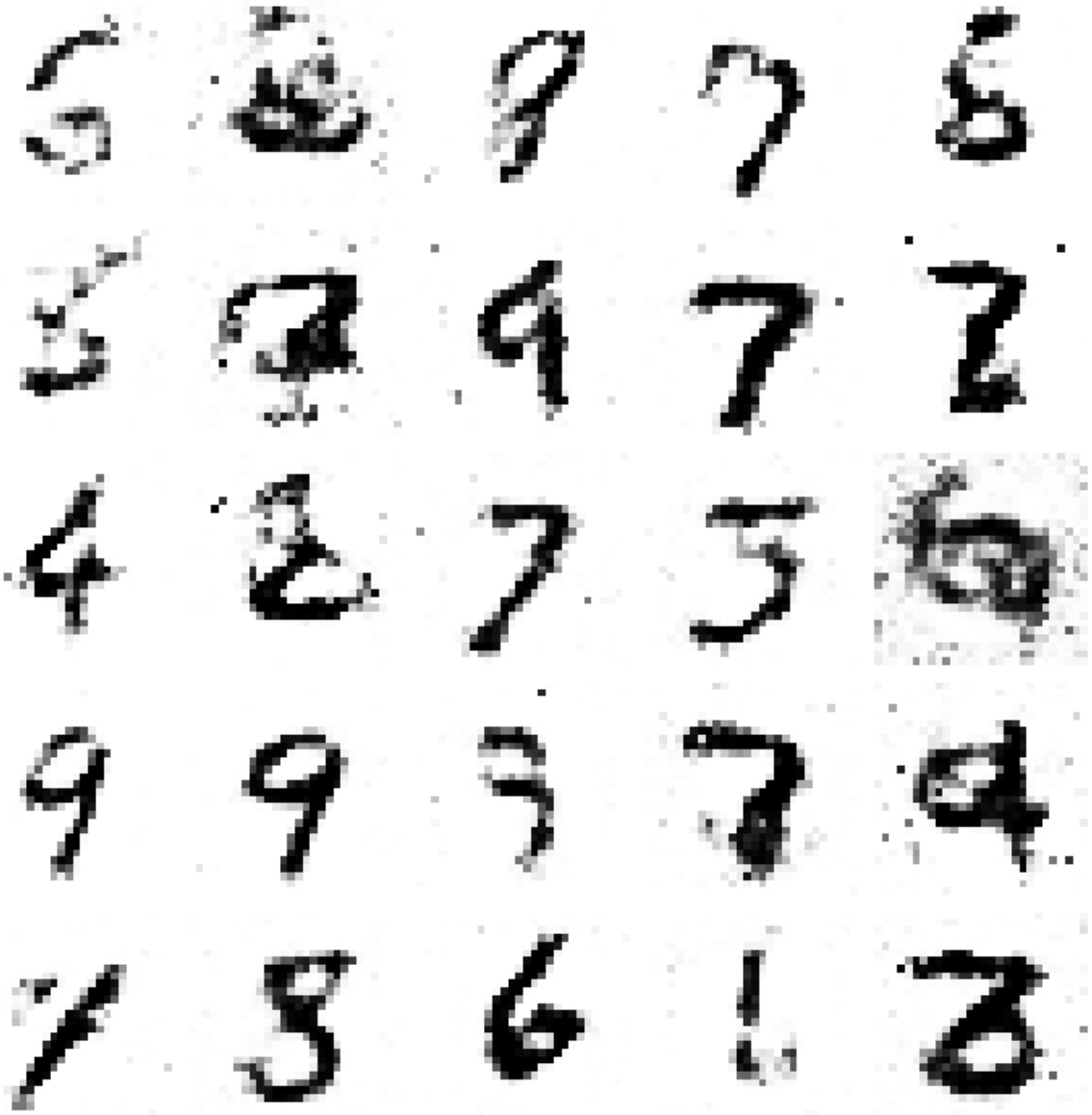

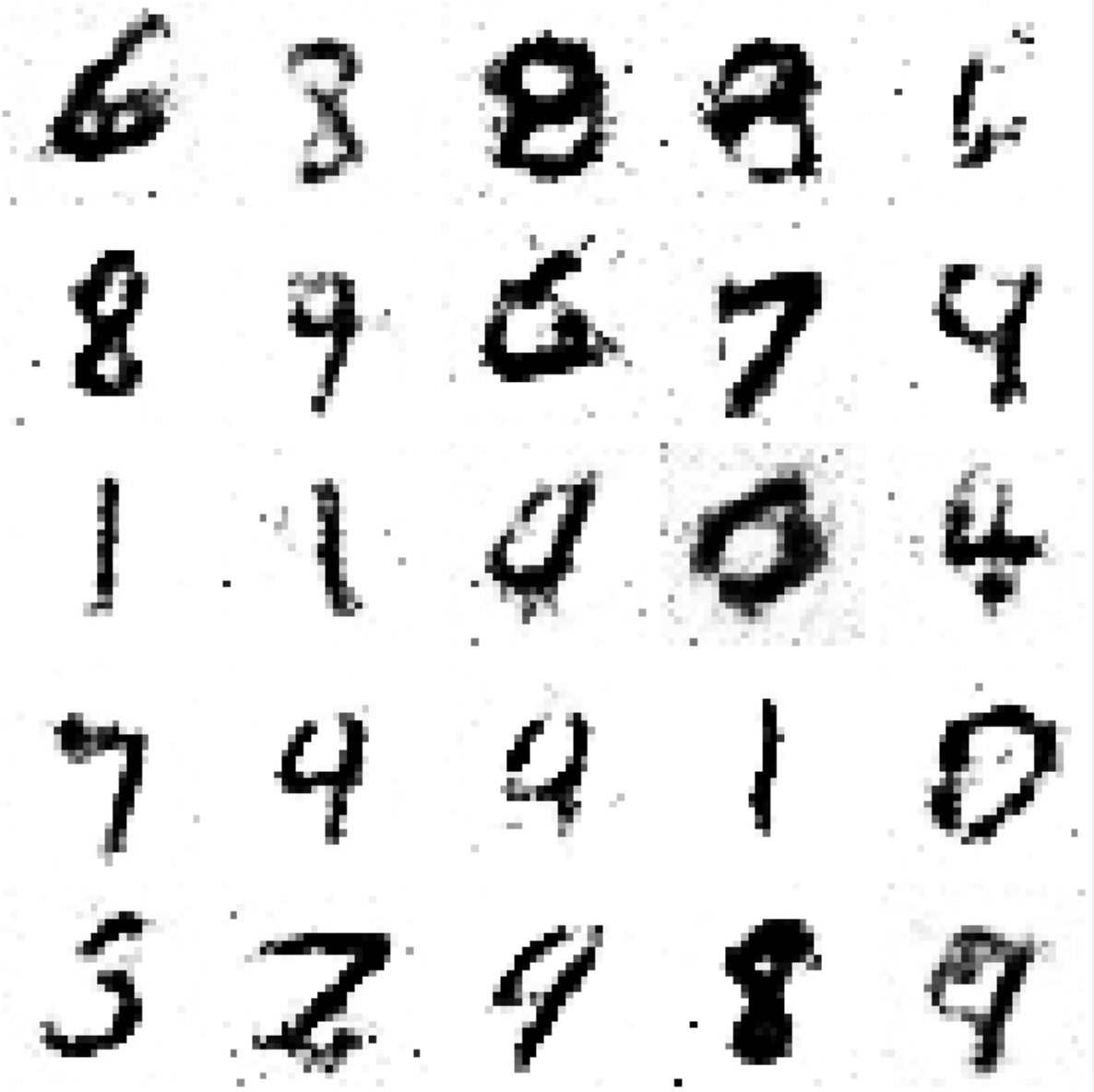

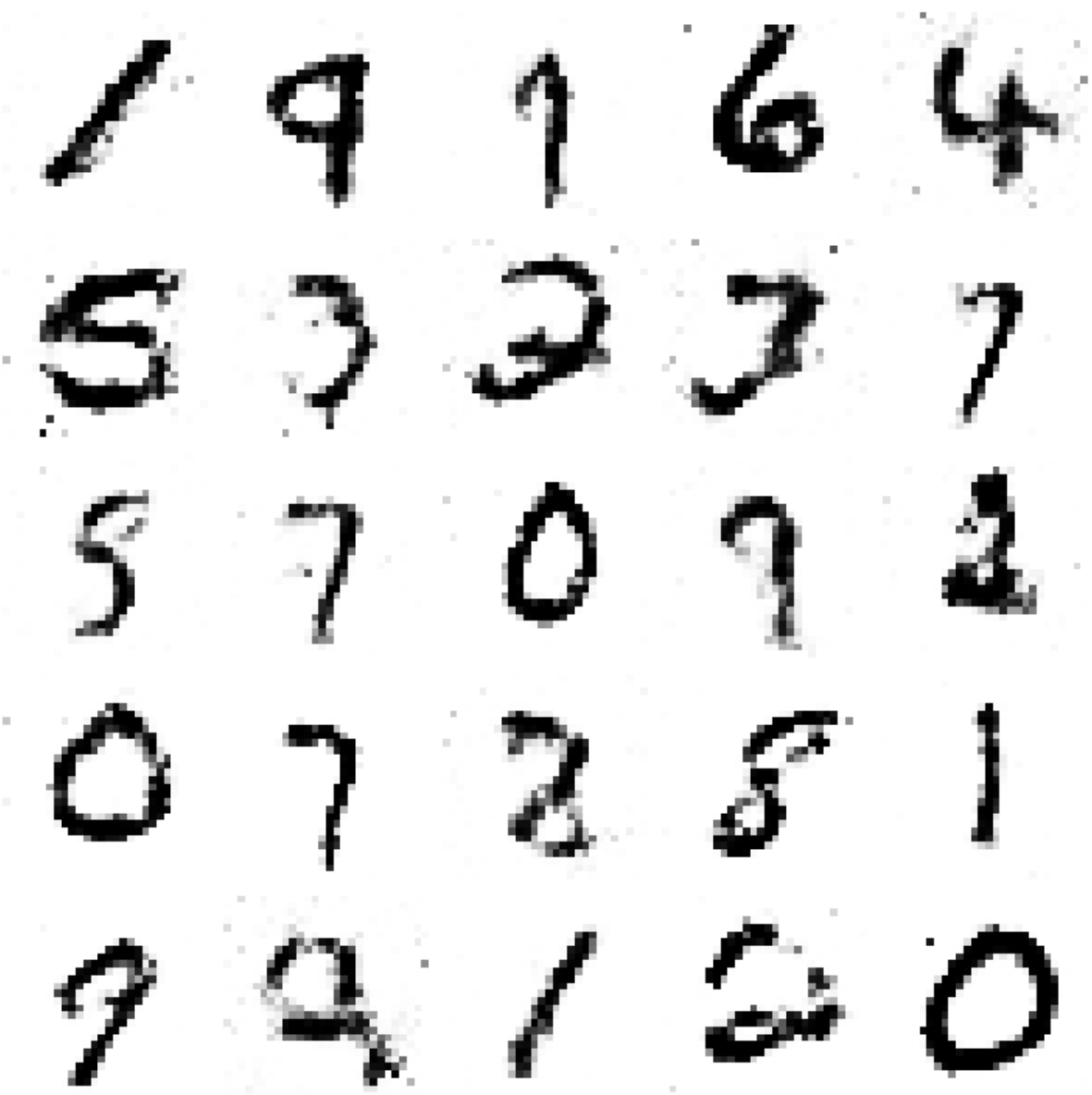

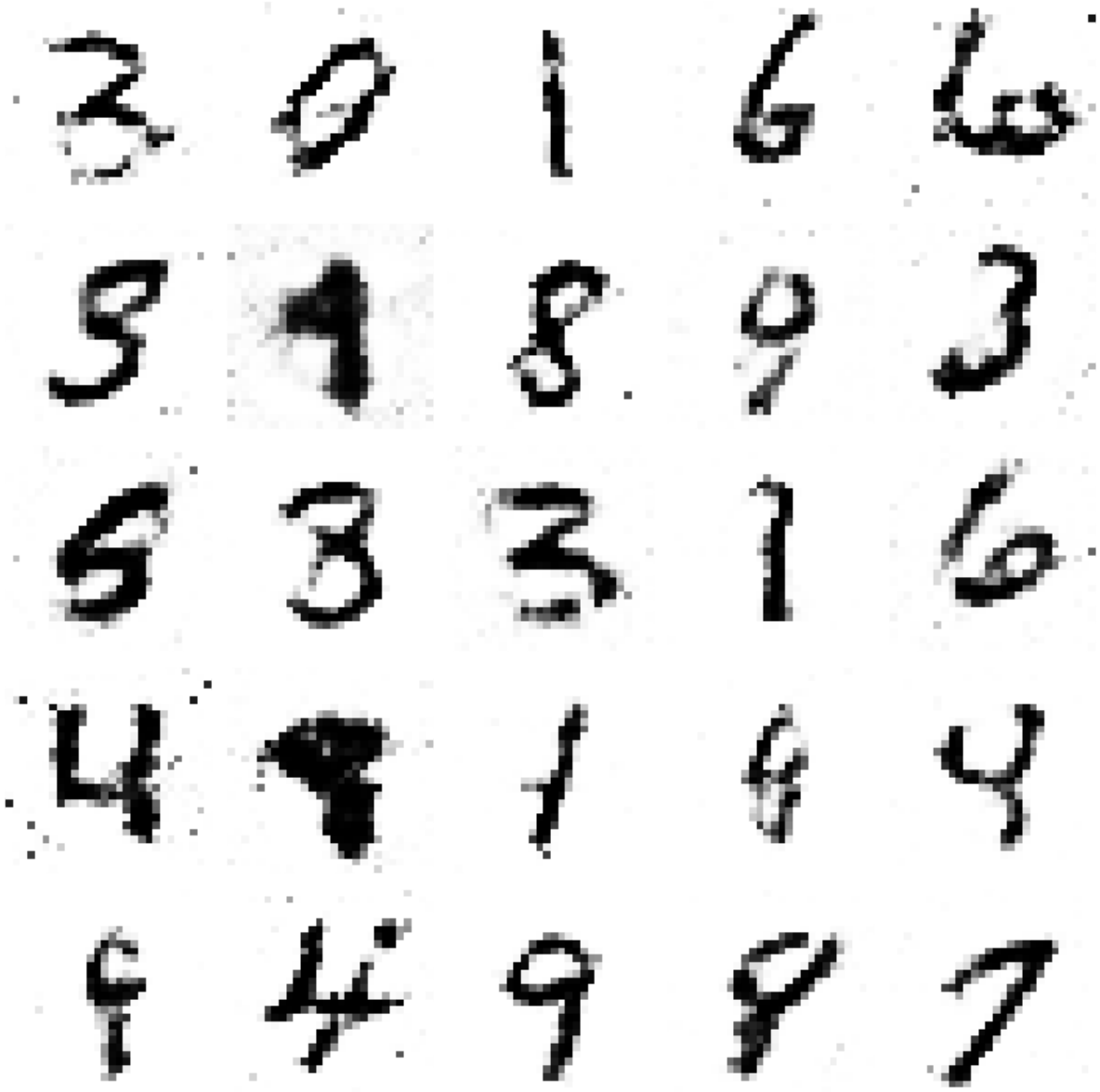

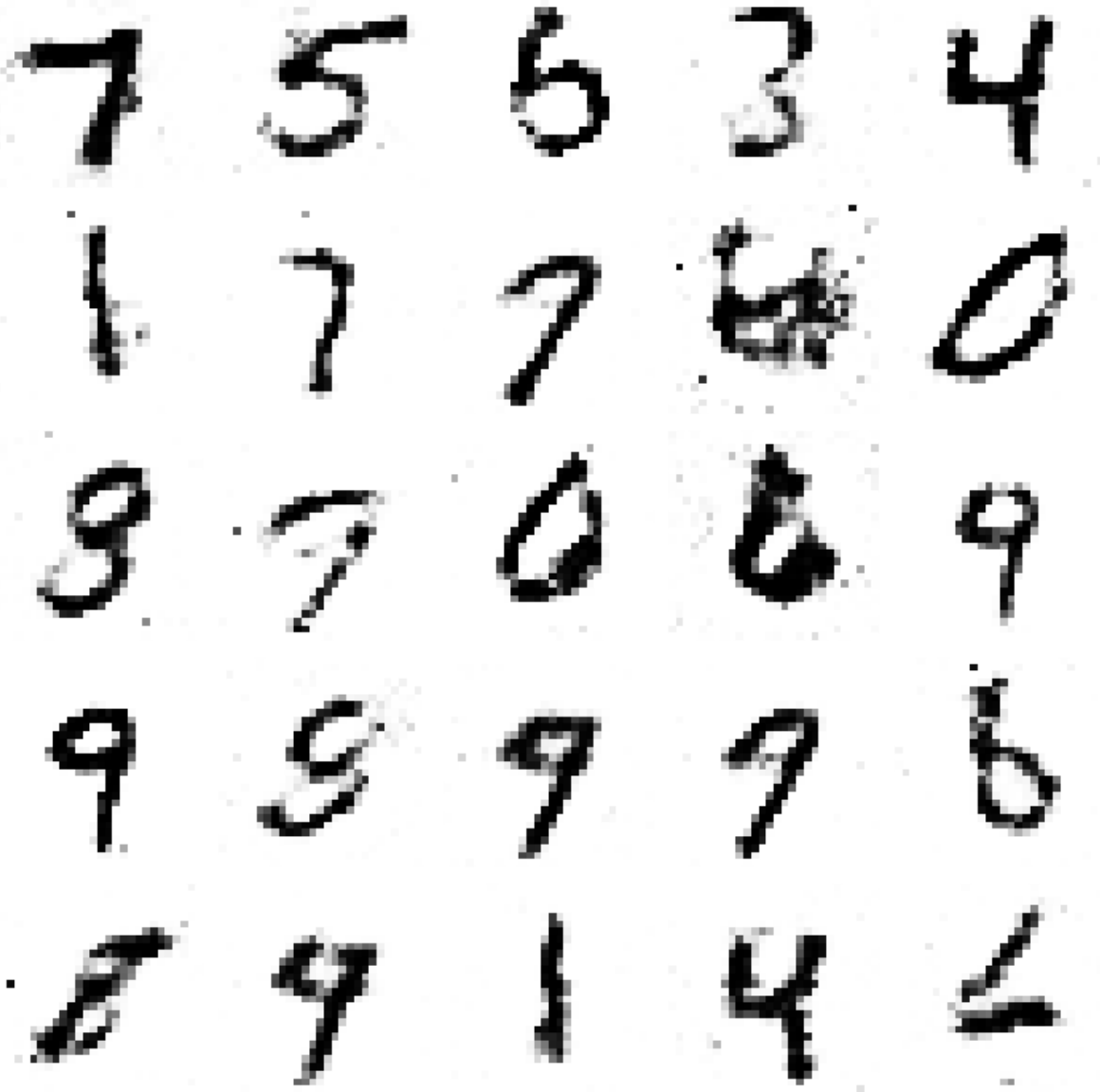

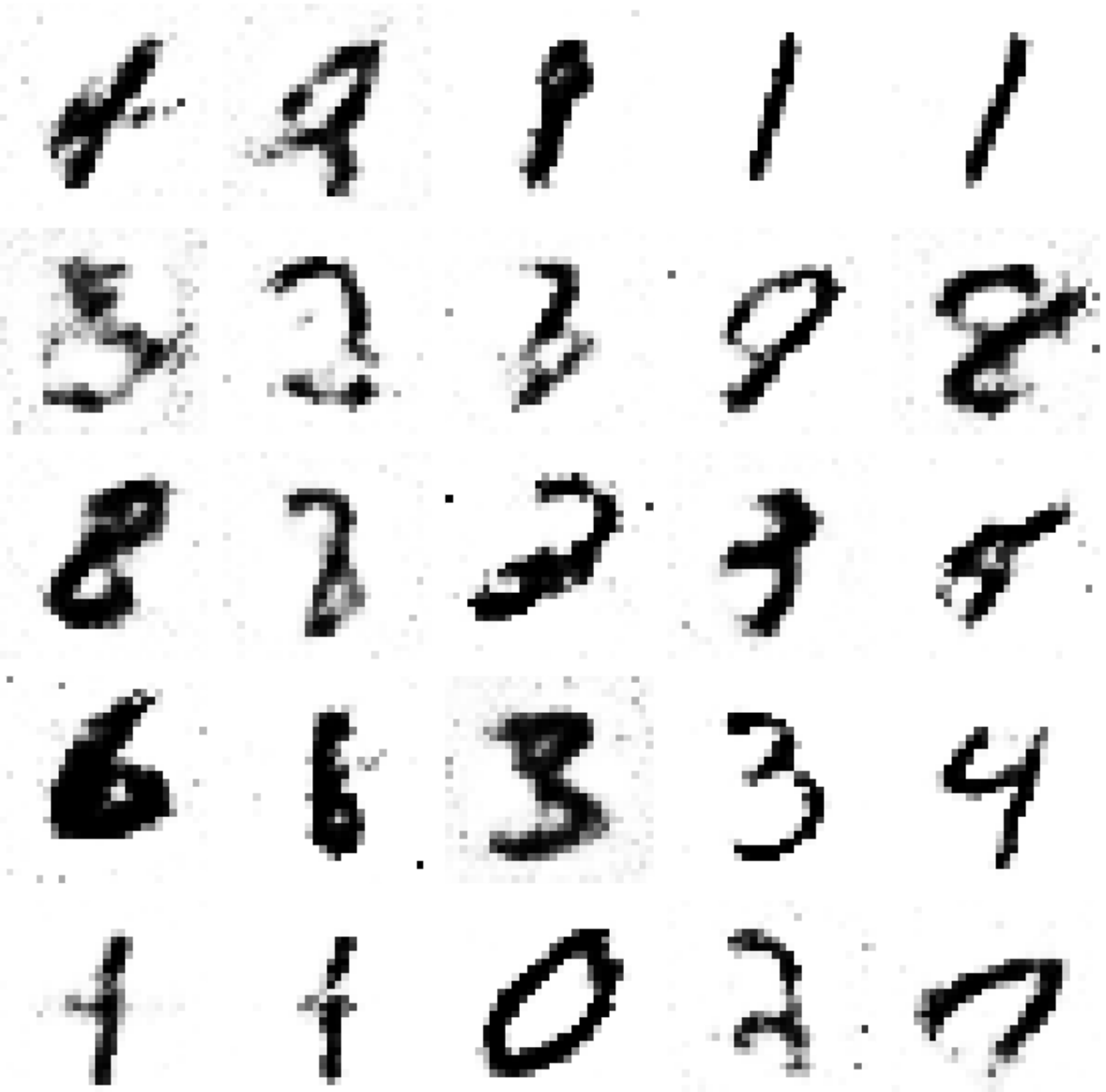

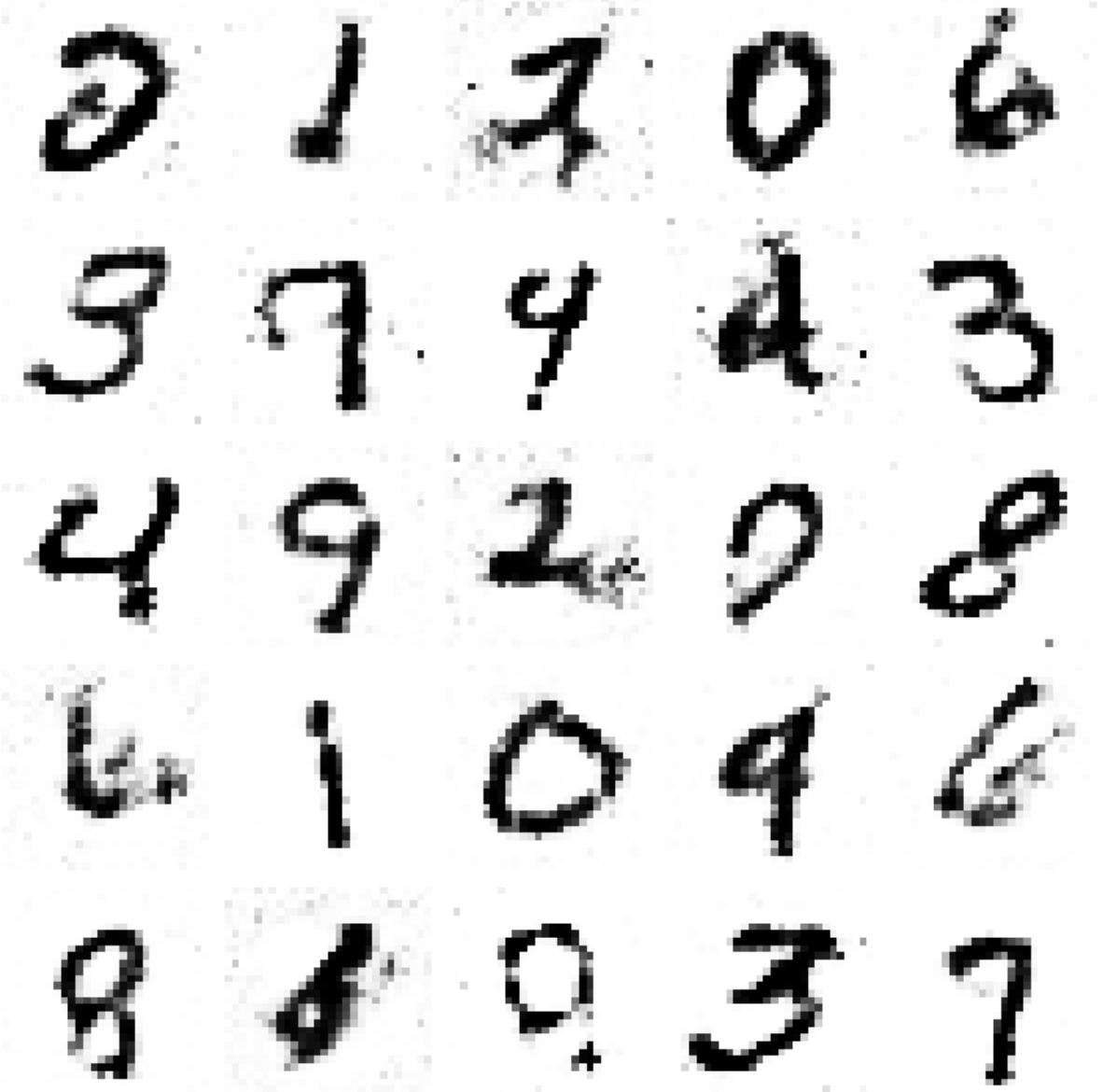

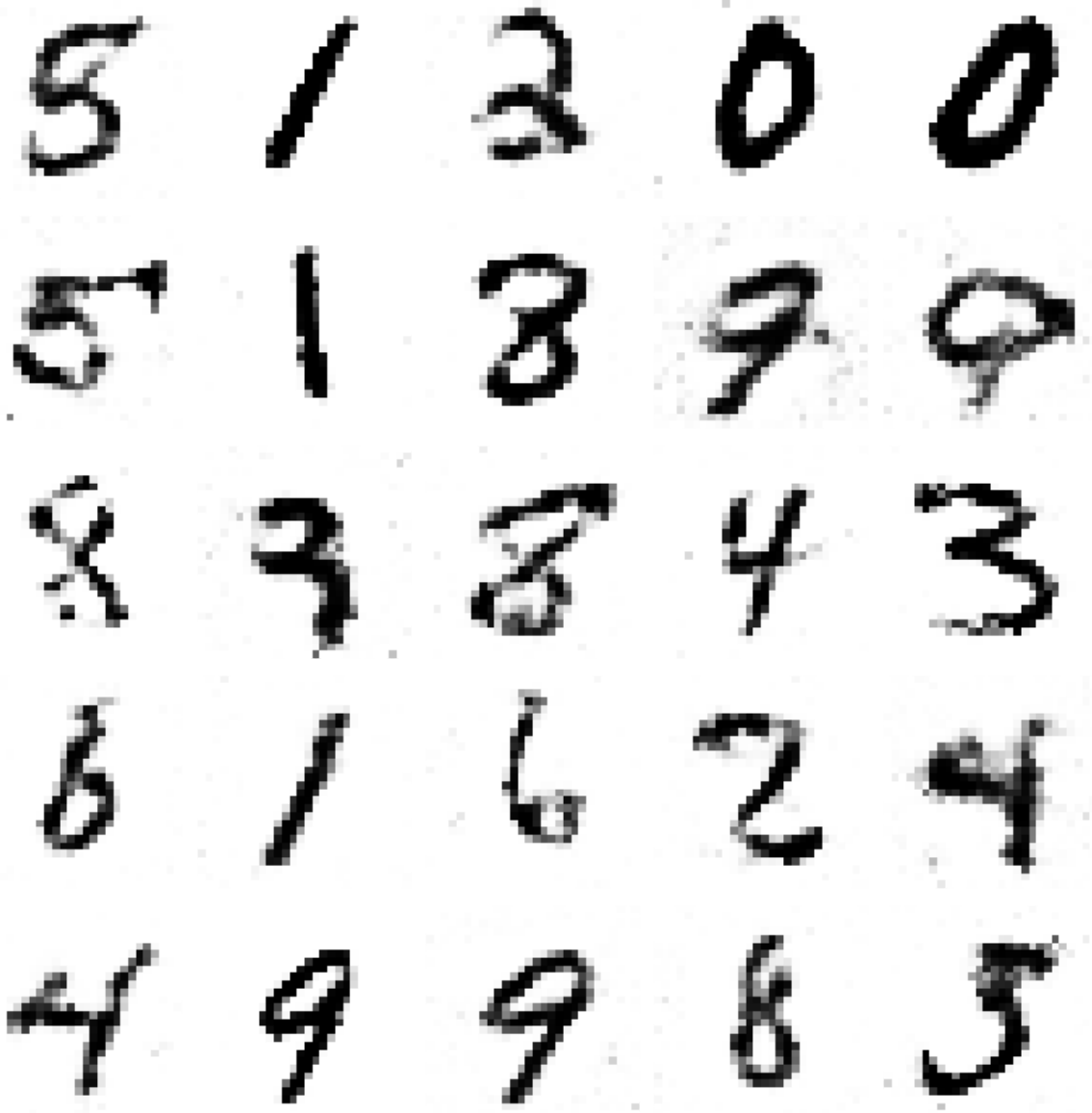

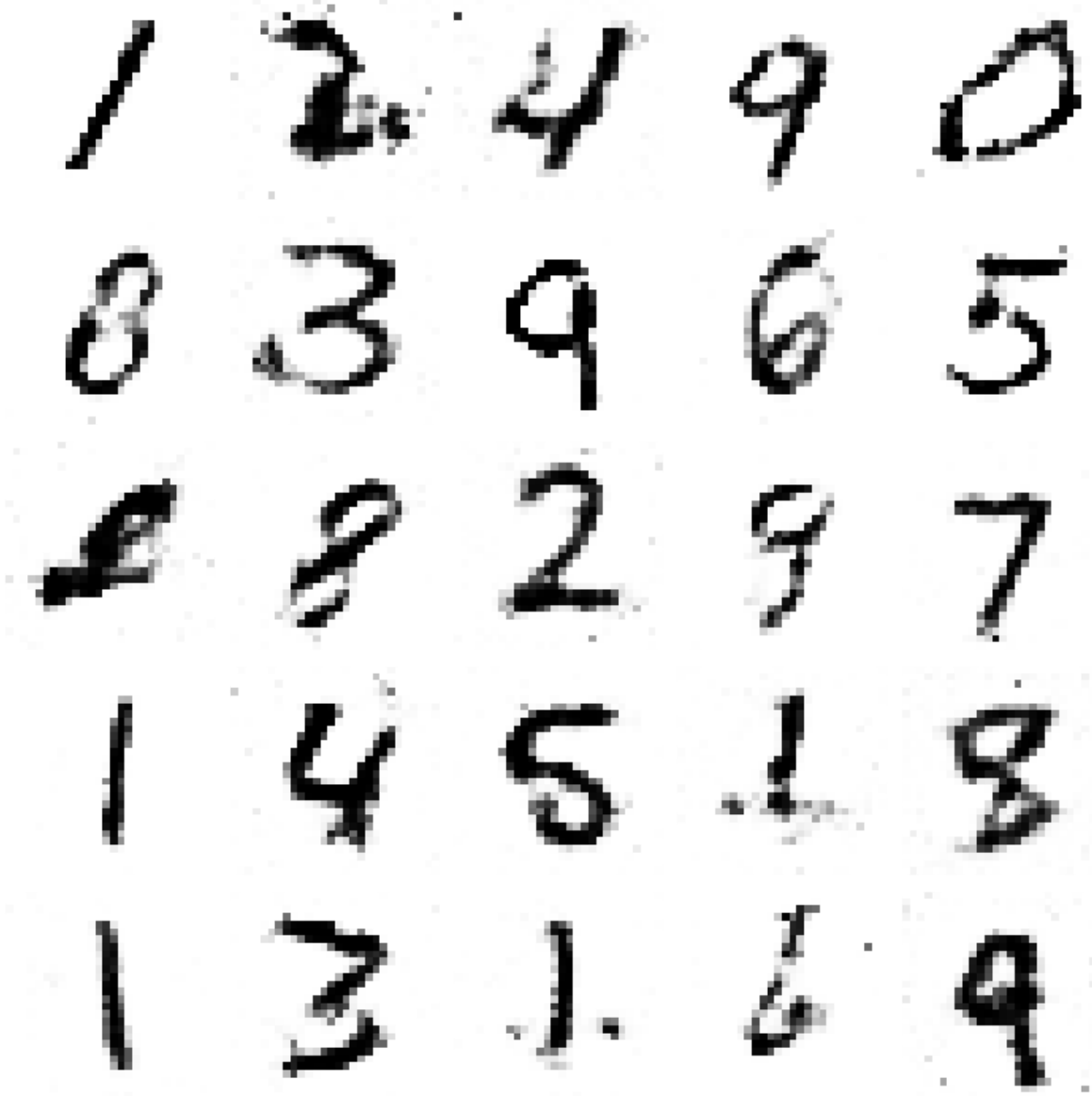

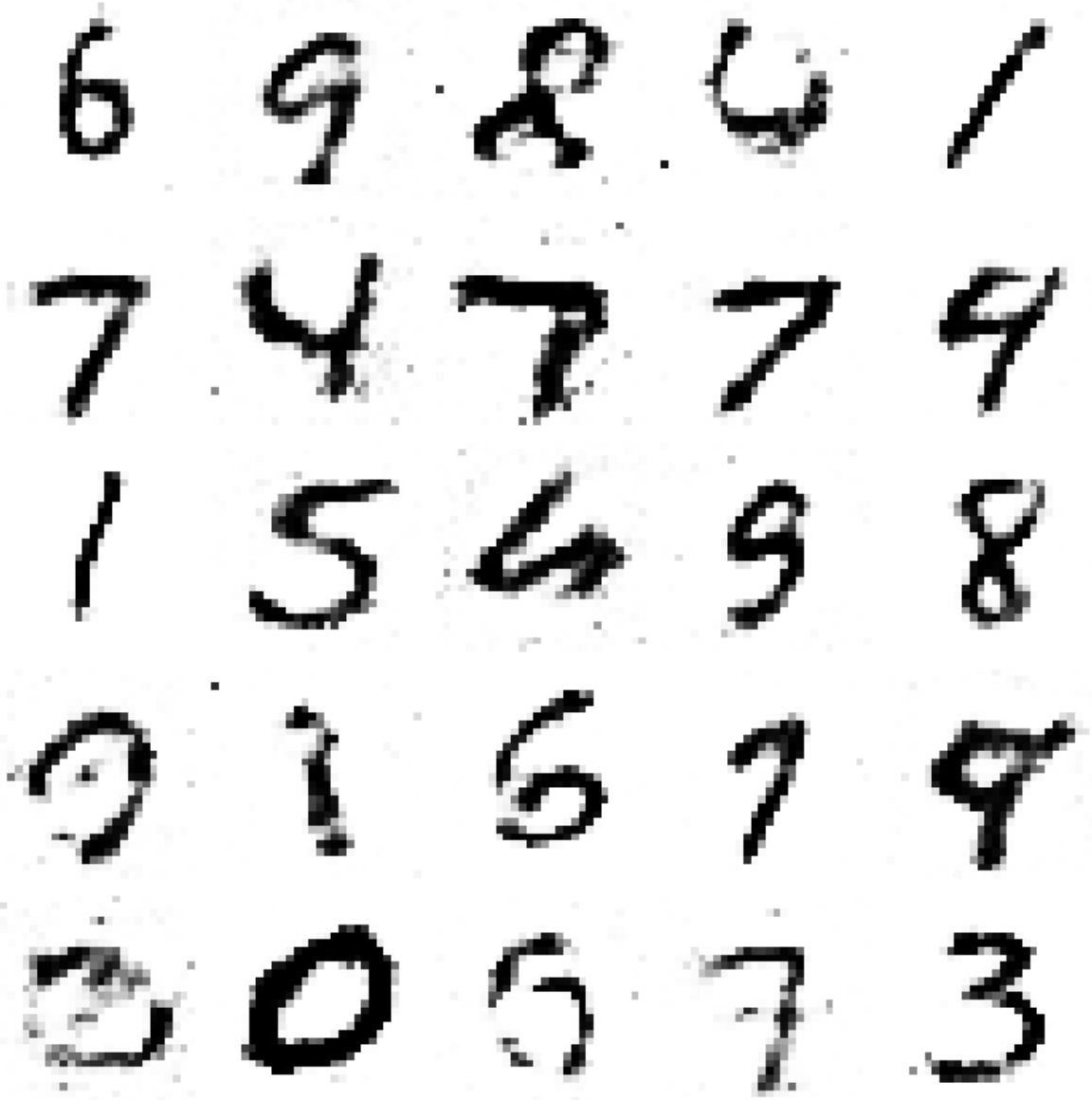

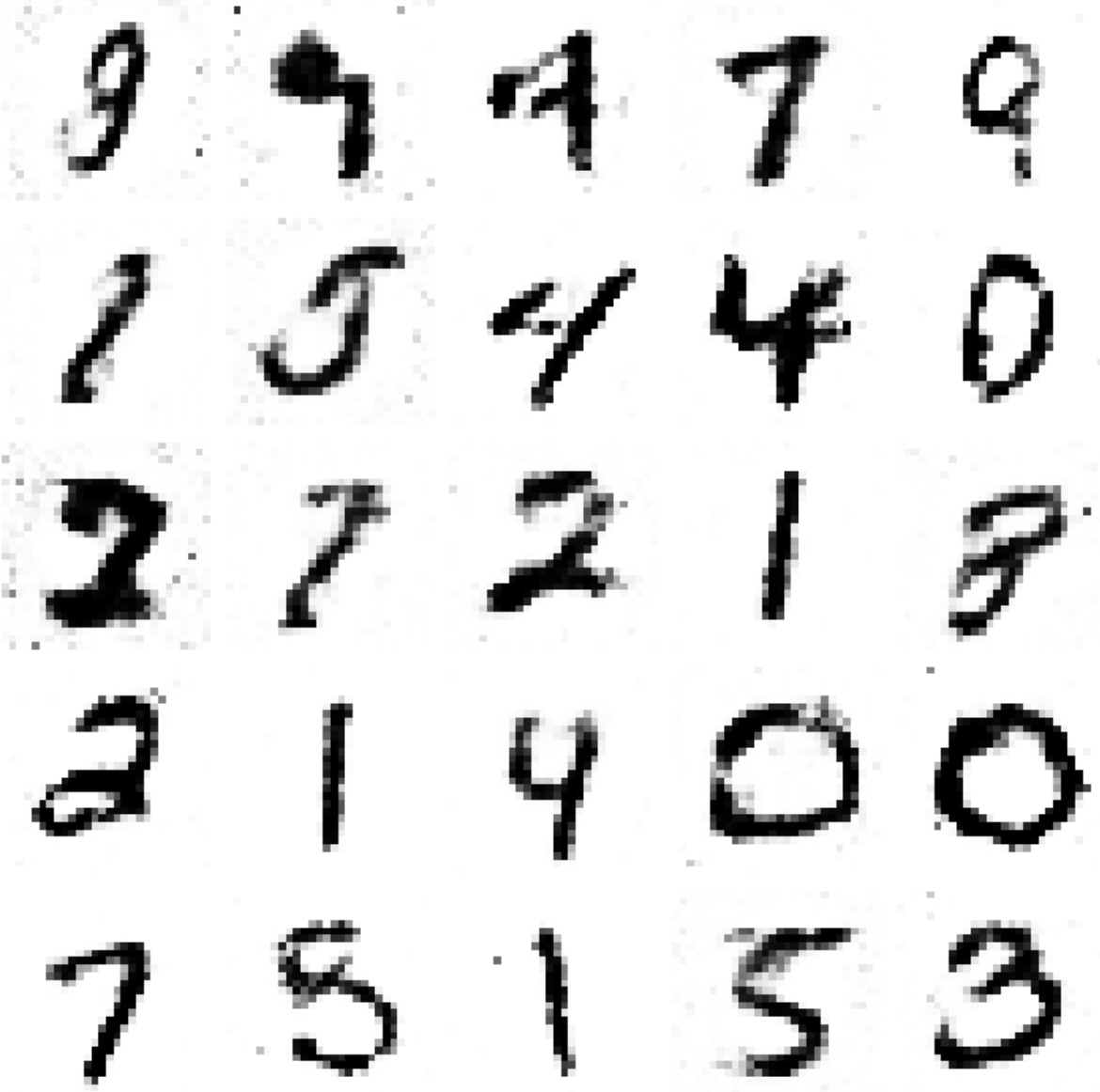

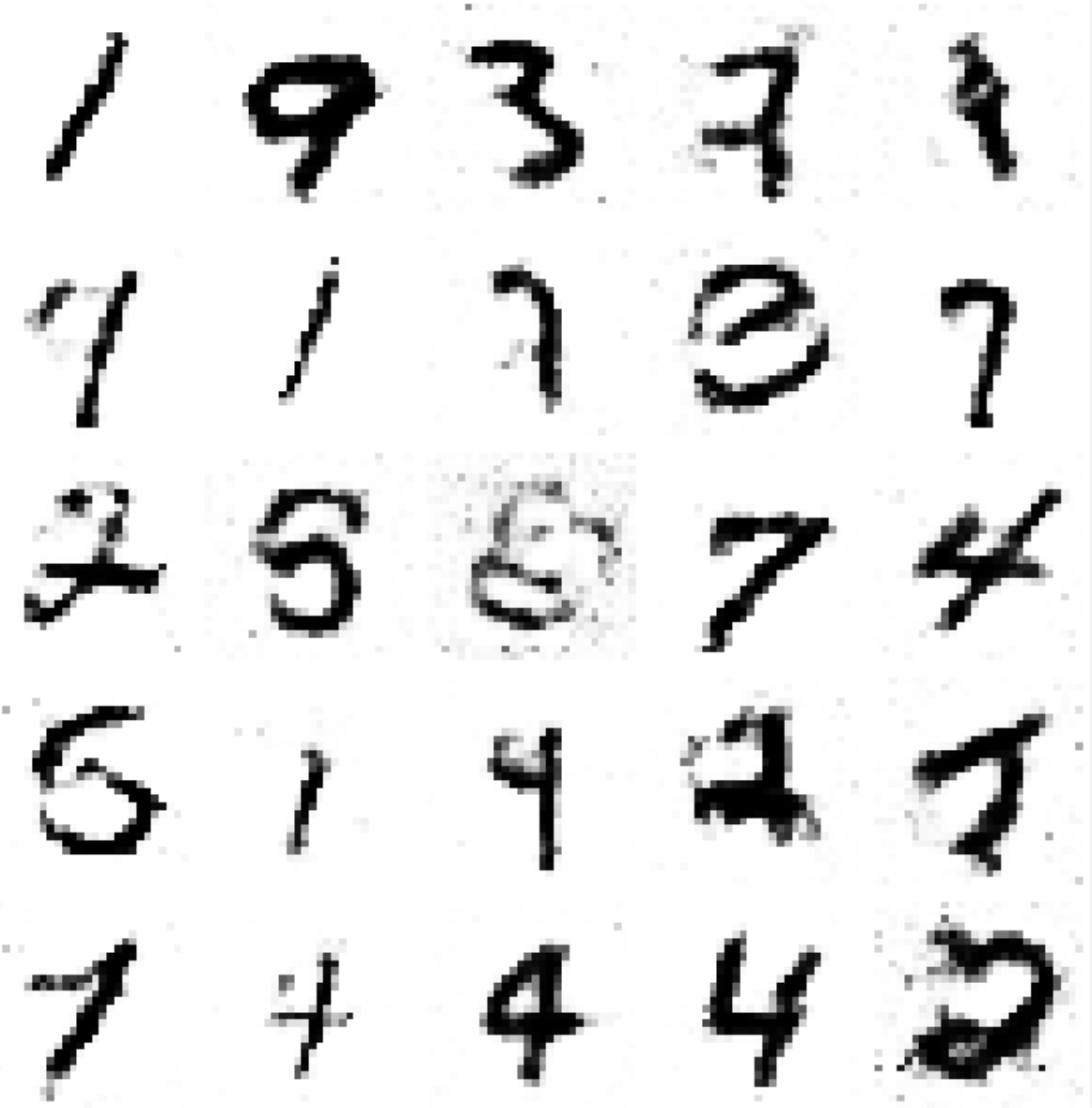

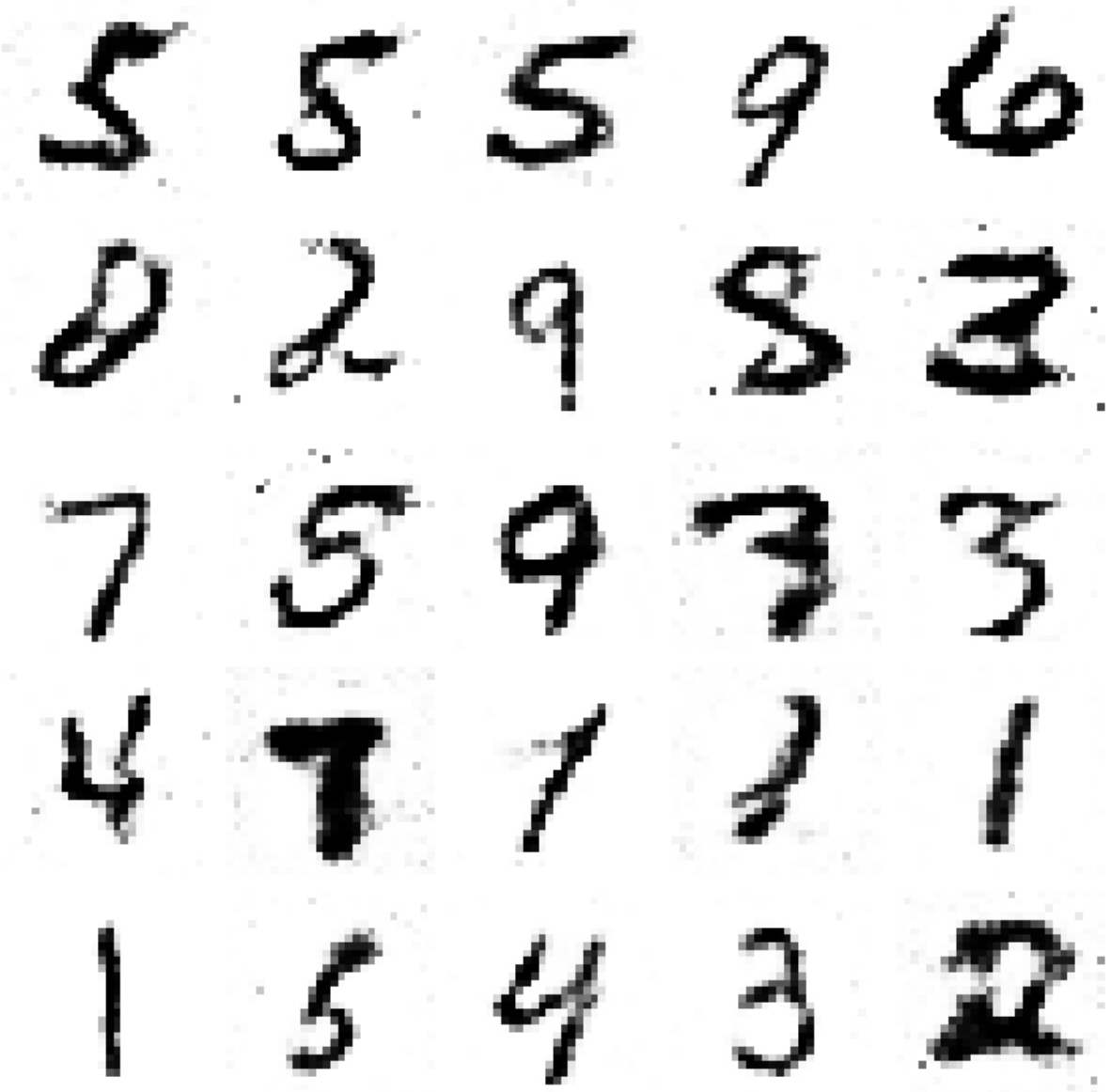

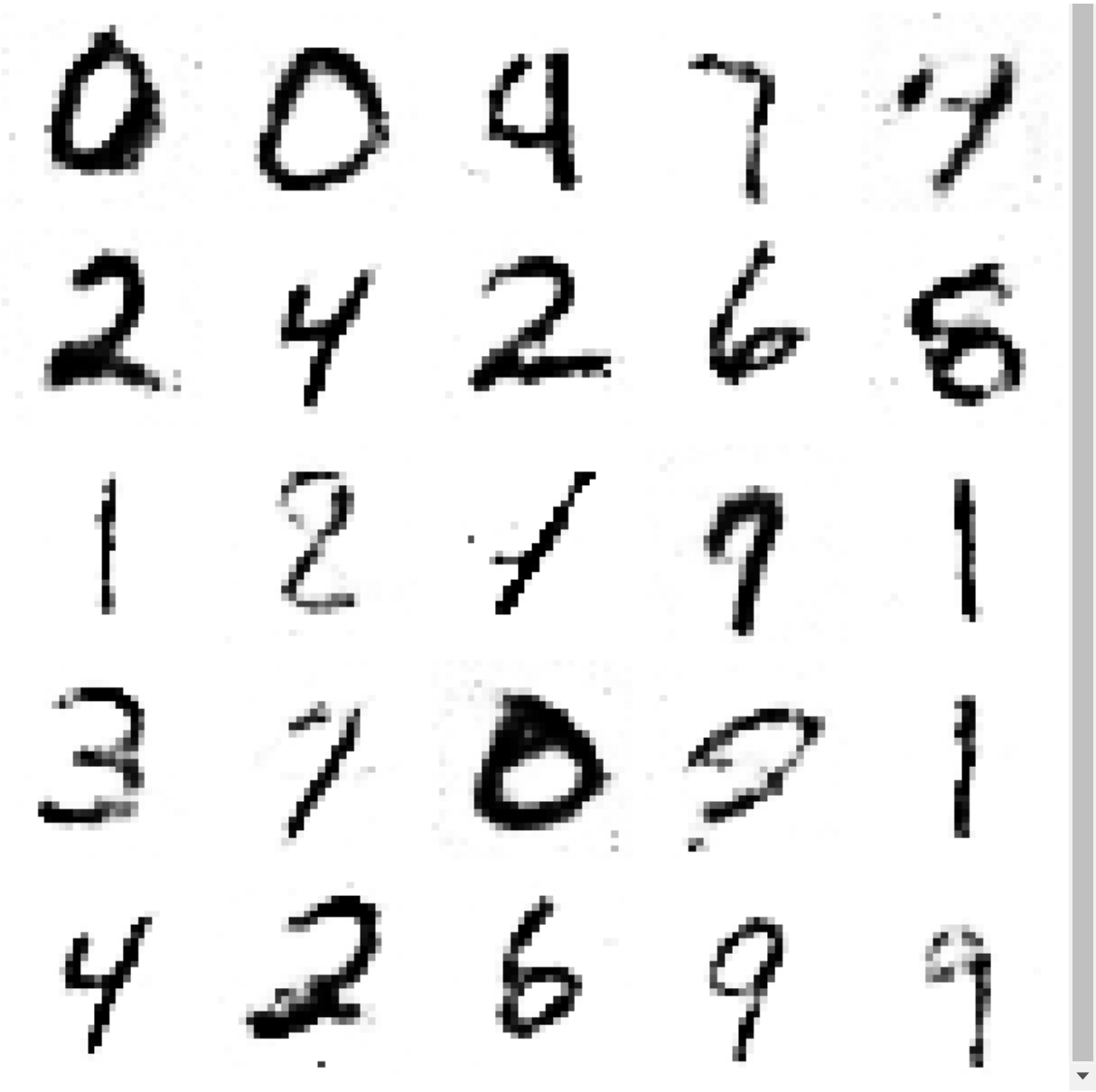

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