PES UNIVERSITY

# ENVIRONMENTAL STUDIES AND LIFE SCIENCES

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# ENVIRONMENTAL STUDIES AND LIFE SCIENCES

## BIOINSPIRED ANN

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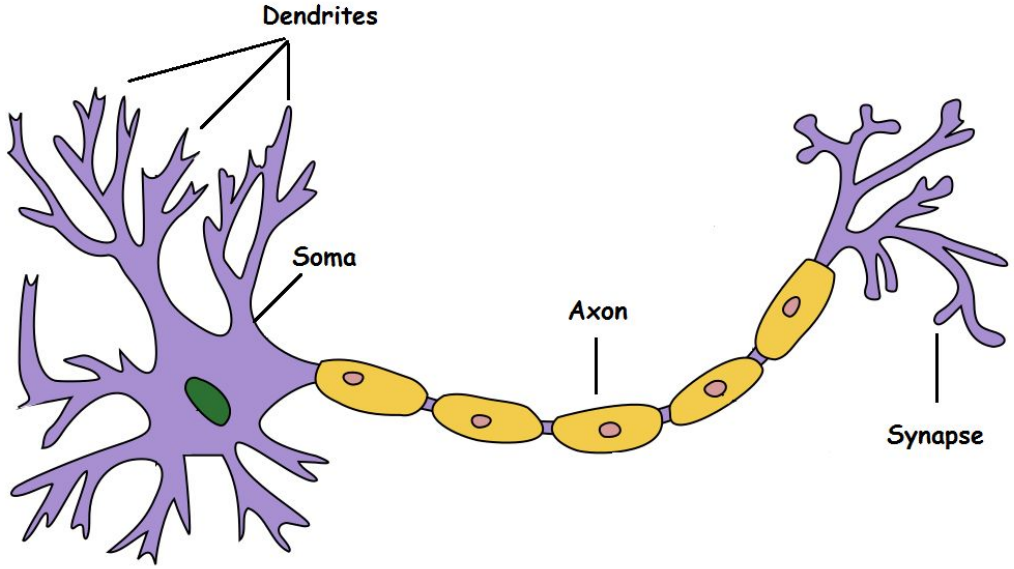
## BIOINSPIRED ANN

- A biological neuron has three types of main components; dendrites, soma (or cell body) and axon.
- Dendrites receives signals from other neurons.
- The soma, sums the incoming signals. When sufficient input is received, the cell fires; that is it transmit a signal over its axon to other cells.

**Human Biological Neuron**




towardsdatascience.com

## BIOINSPIRED ANN

- In the human brain, a typical neuron collects signals from others through a host of fine structures called *dendrites*.
- The neuron sends out spikes of electrical activity through a long, thin stand known as an *axon*, which splits into thousands of branches.
- At the end of each branch, a structure called a *synapse* converts the activity from the axon into electrical effects that inhibit or excite activity in the connected neurons.

## BIOINSPIRED ANN

**Artificial Neural Network-ANN** is an information processing system that has certain performance characteristics in common with biological nets.

Several key features of the processing elements of ANN are suggested by the properties of biological neurons:

- The processing element receives many signals.
- Signals may be modified by a weight at the receiving synapse.
- The processing element sums the weighted inputs.
- Under appropriate circumstances (sufficient input), the neuron transmits a single output.
- The output from a particular neuron may go to many other neurons.

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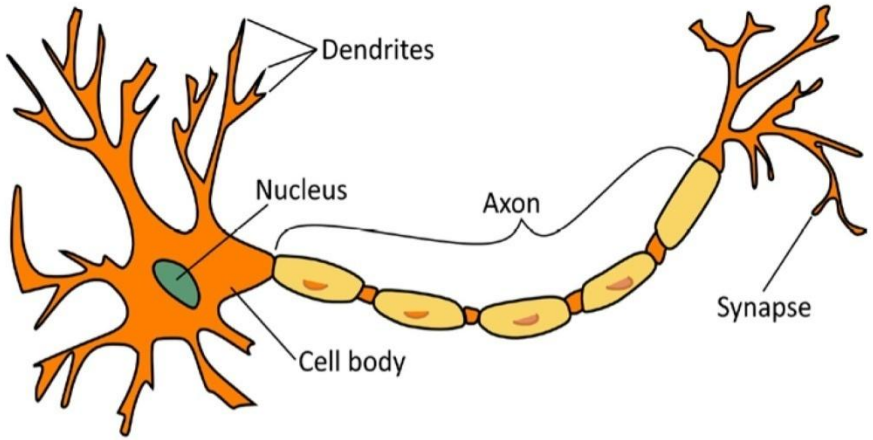
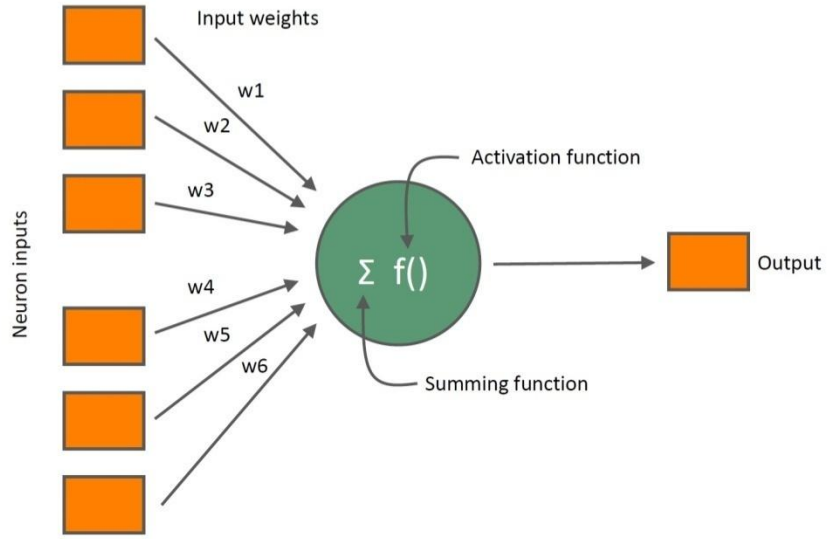
- From experience: examples / training data
- Strength of connection between the neurons is stored as a weight-value for the specific connection.
- Learning the solution to a problem = changing the connection weights

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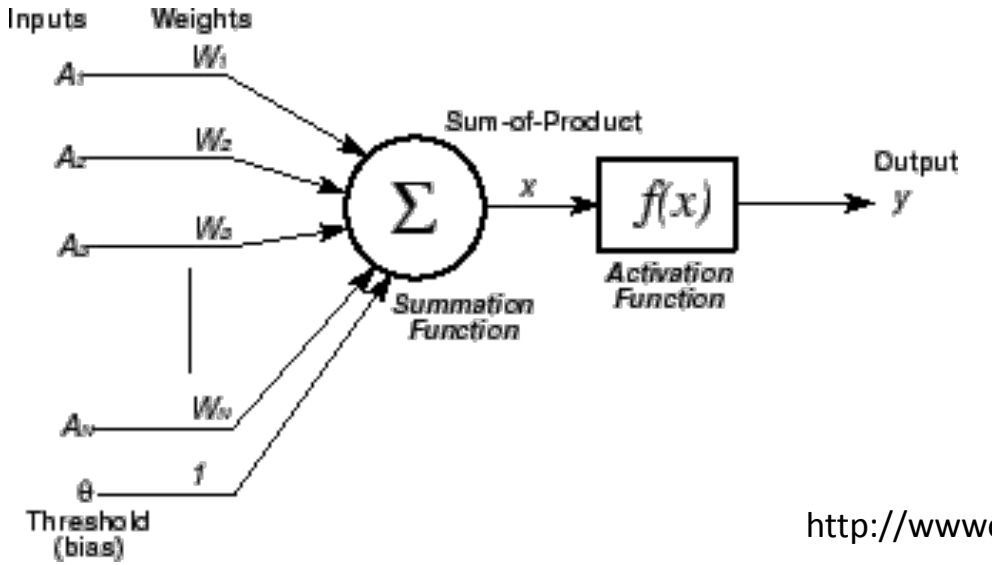
ANNs have been developed as generalizations of mathematical models of neural biology, based on the assumptions that:

- Information processing occurs at many simple elements called neurons.
- Signals are passed between neurons over connection links.
- Each connection link has an associated weight, which, in typical neural net, multiplies the signal transmitted.
- Each neuron applies an activation function to its net input to determine its output signal.

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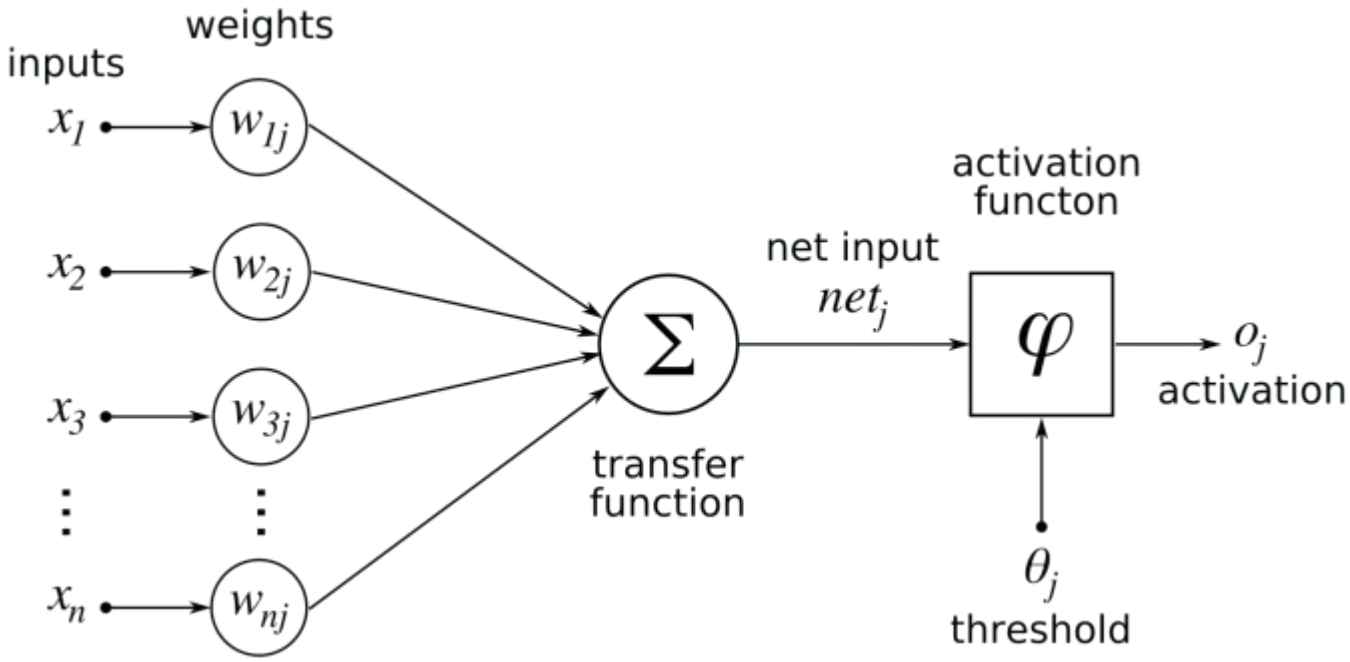
### Artificial Neural Network




**-A neuron receives input, determines the strength or the weight of the input, calculates the total weighted input, and compares the total weighted with a value (threshold)**
**-The value is in the range of 0 and 1**
**- If the total weighted input greater than or equal the threshold value, the neuron will produce the output, and if the total weighted input less than the threshold value, no output will be produced**

https://bdtechtalks.com/

## Characterization

- Architecture
  - a pattern of connections between neurons
    - Single Layer Feedforward
    - Multilayer Feedforward
    - Recurrent
- Strategy / Learning Algorithm
  - a method of determining the connection weights
    - Supervised
    - Unsupervised
    - Reinforcement
- Activation Function
  - Function to compute output signal from input signal

## Some Properties of Artificial Neural Networks

- Assembly of simple processors
- Information stored in connections
- Massively Parallel
- Massive connectivity
- Fault Tolerant
- Learning and Generalization Ability
- Robust
- Individual dynamics different from group dynamics
- All these properties may **not** be present in a particular network

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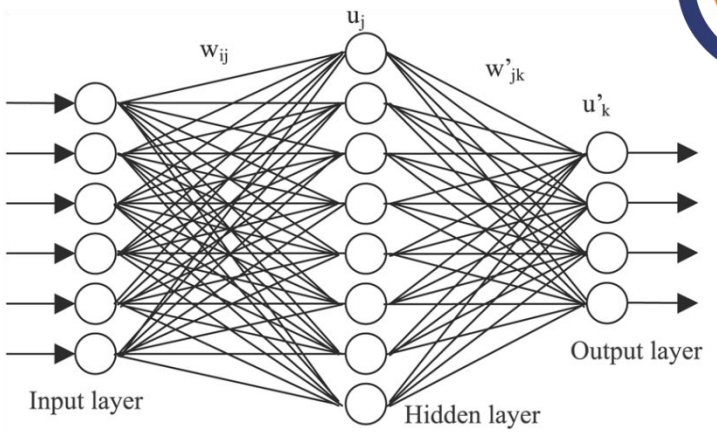
- Input Layer - The activity of the input units represents the raw information that is fed into the network.
- Hidden Layer - The activity of each hidden unit is determined by the activities of the input units and the weights on the connections between the input and the hidden units.
- Output Layer - The behavior of the output units depends on the activity of the hidden units and the weights between the hidden and output units.
- This simple type of network is interesting because the hidden units are free to construct their own representations of the input.
- The weights between the input and hidden units determine when each hidden unit is active, and so by modifying these weights, a hidden unit can choose what it represents.

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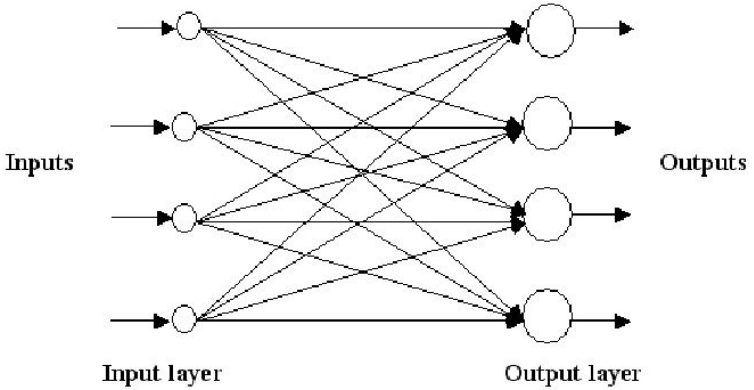
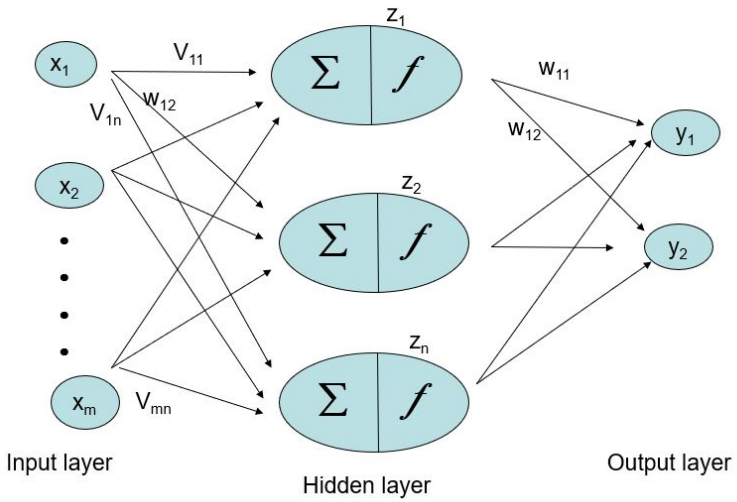
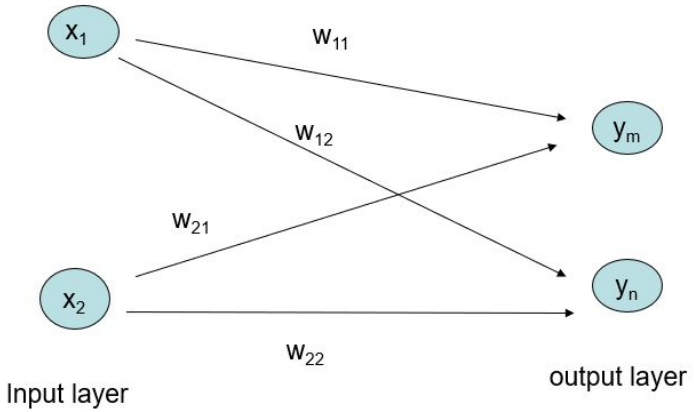


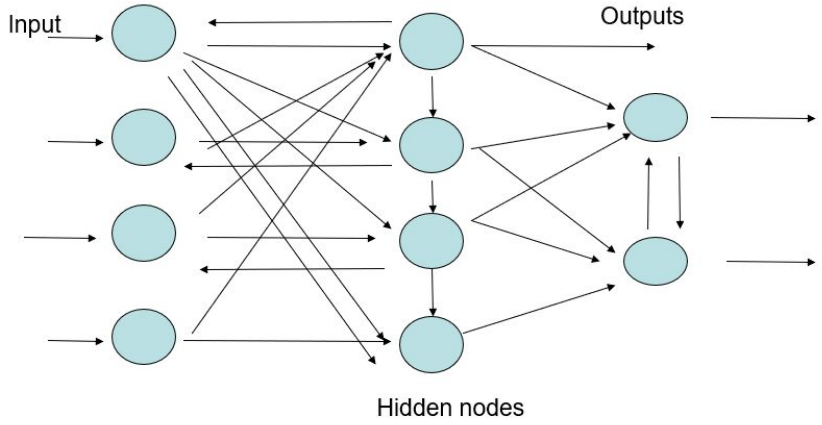

Multilayer Neural Network




Single Layer Feedforward NN




Recurrent NN

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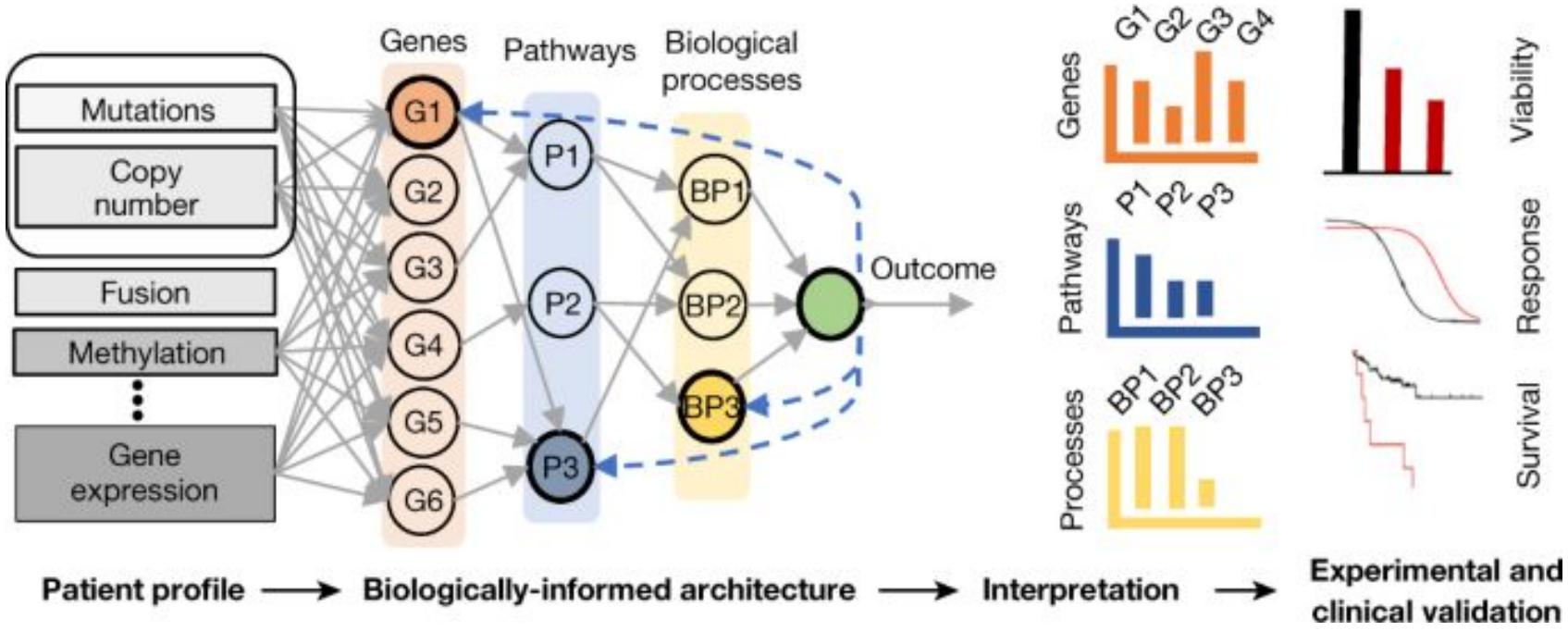


P-NET is a neural network architecture that encodes different biological entities into a neural network language with customized connections between consecutive layers (that is, features from patient profile, genes, pathways, biological processes and outcome). The trained P-NET provides a relative ranking of nodes in each layer to inform generation of biological hypotheses. Solid lines show the flow of information from the inputs to generate the outcome and dashed lines show the direction of calculating the importance score of different nodes. Candidate genes are validated to understand their function and mechanism of action.

https://doi.org/10.1038/s41586-021-03922-4

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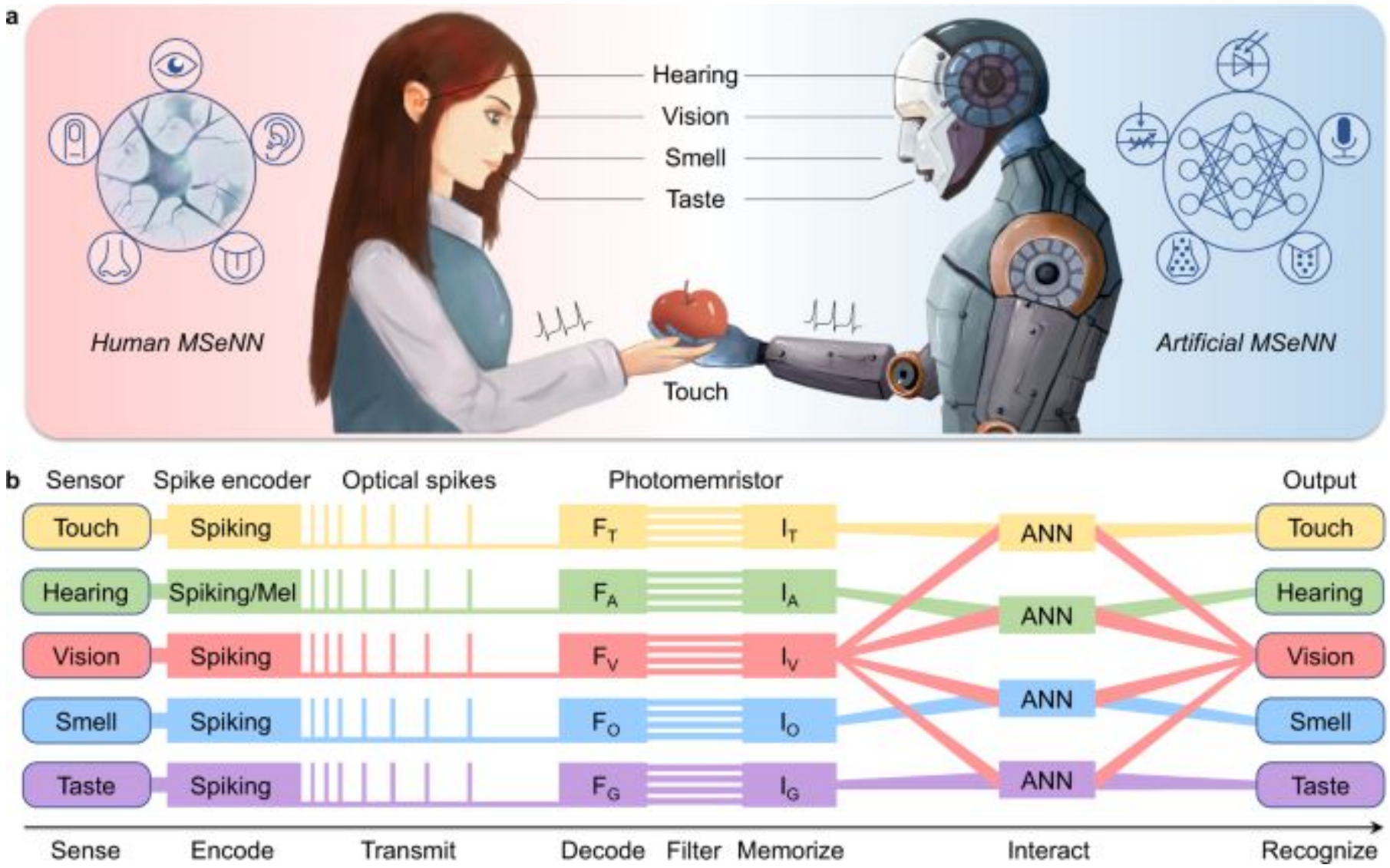


https://doi.org/10.1038/s41467-021-21404-z

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## BIOINSPIRED ANN

**a** Inspired by the five primary sensory systems (vision, touch, hearing, smell, taste) in the human MSeNN (bioinspired spiking multisensory neural network) and their interaction via neural networks, the artificial MSeNN consists of five artificial sensory systems and their integration via ANNs.

**b** Operational diagram of the artificial MSeNN. Sensors (photodetectors, pressure sensors, sound detectors, and simulated smell and taste receptors) convert external stimuli to potentials. Spike encoders encode potentials into optical spikes for communication. The transmitted information is decoded, filtered, and memorized by photomemristors, and the signals are crossmodally integrated and associated by ANNs for crossmodal recognition and imagination.

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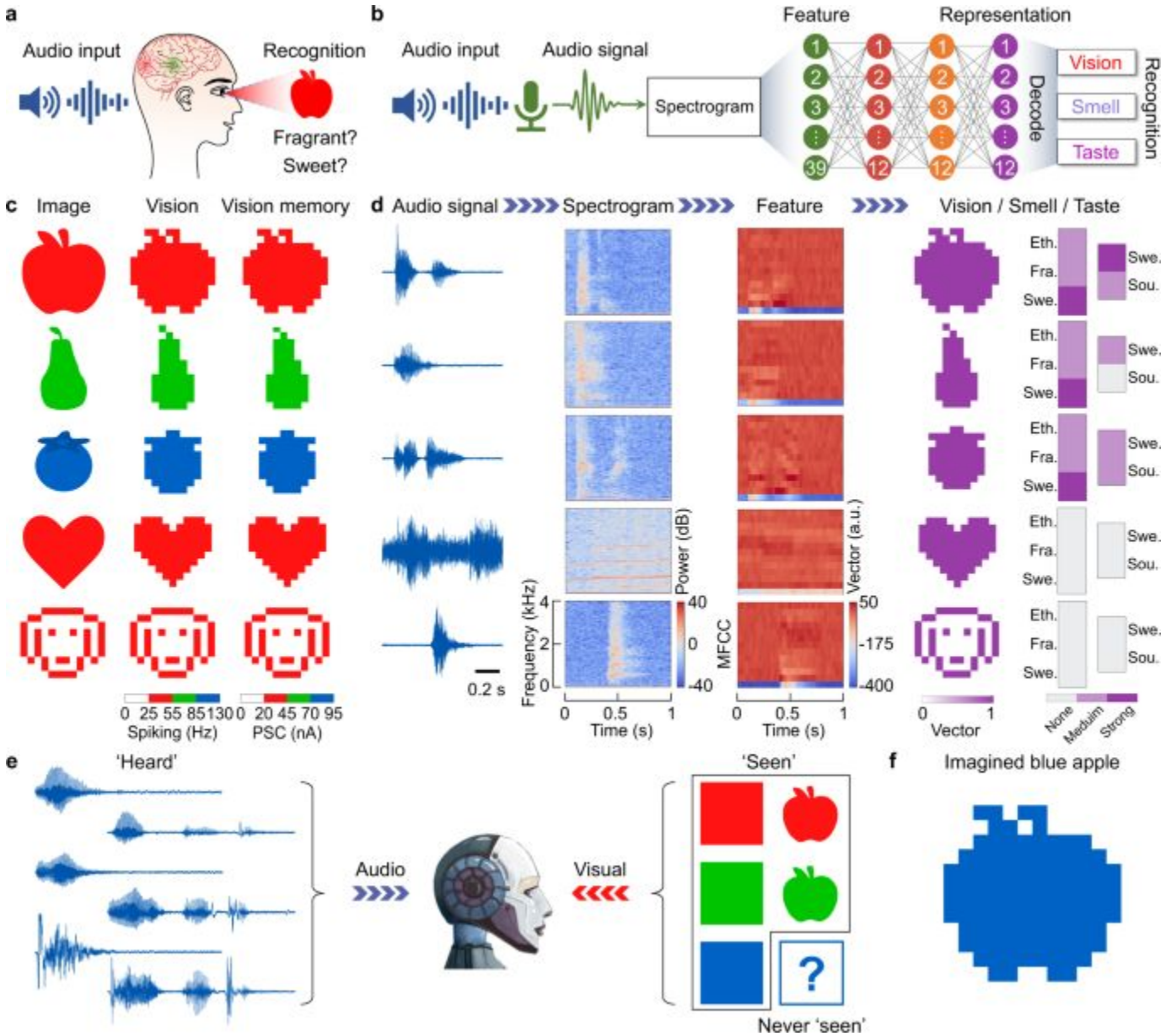
## BIOINSPIRED ANN

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**a** Illustration of the human ability to recognize and visualize audio input.
**b** Schematic of the artificial auditory-vision/olfactory/gustatory system. Spectrograms convert the audio inputs into 13 × 3-dimensional features feeding the ANN. Visual data processed by 12 × 12 photodetectors and photomemristors, together with olfactory and gustatory vectors are encoded into 12-dimensional features via an autoencoder to represent the image, smell, and taste information. The ANN consists of 4 layers with 39 input, 12 hidden, 12 hidden, and 12 output neurons (image/smell/taste representation).
**c** Detected image and vision memory of an apple, pear, blueberry, heart, and dog. The memorized vision, smell, and taste vectors are encoded into the representations via the autoencoder to supervise the training of the ANN with audio inputs.
**d** Recognized and reproduced image, smell and taste of an apple, pear, blueberry, and the reproduced image of a heart and dog upon associated audio input.
**e** Illustration of supervised training of the auditory-vision system using colors and apples.
**f** Imagination of a blue apple by the trained system when audio input is given after training.

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# THANK YOU

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